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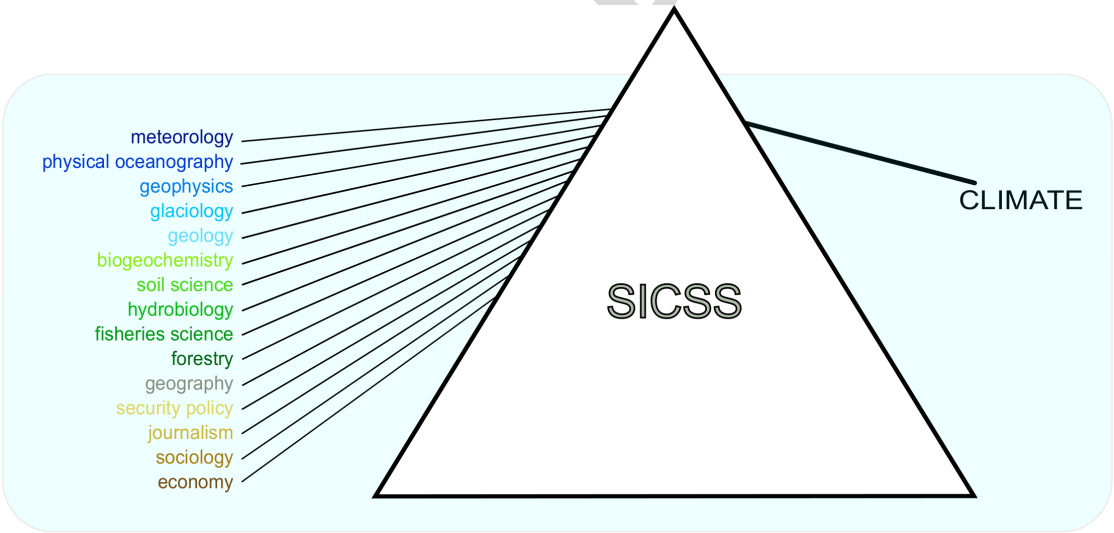
School of Integrated Climate System Sciences (SICSS)
Faculty of Mathematics, Informatics and Natural Sciences (MIN)
University of Hamburg

Master of Science
Integrated Climate System Sciences
(M.Sc. ICSS)

Module Handbook

Version 2.016 (winter term)



July 6, 2016

M.Sc. Integrated Climate System Sciences at the University of Hamburg

Introduction. The English language M.Sc. program "Integrated Climate System Sciences" (ICSS) is part of the School of Integrated Climate System Sciences (SICSS) at the Universität Hamburg. It has been established at the Department of Earth Sciences within the Faculty of Mathematics, Informatics and Natural Sciences (MIN) in close collaboration with the Faculty of Economics and Social Sciences.

Structure. The M.Sc. degree program educates students in climate system sciences, integrating elements of atmospheric, hydrospheric, cryospheric and biospheric natural sciences with economics and social sciences. The program has a focus on physics, and offers specialization in three tracks: "Physics of the Climate System" (ICSS-P), "Biogeochemistry of the Climate System" (ICSS-B) and "Climate-related Economics and Social Sciences" (ICSS-ES). The three tracks represent core scientific and educational elements, integrating student education with cutting edge research. The focus on modelling is internationally unique.

Objectives. The M.Sc. program ICSS is research oriented and imparts knowledge and skills for climate research. Based on a solid background in climate physics, students will be prepared for a career in an interdisciplinary field of science. This includes the ability to communicate with colleagues from different disciplines, to apply a diverse suite of methods from various subject areas to climate-related research questions, as well as the generation, interpretation and combination of scientific results.

Course of studies. The two-year curriculum is subdivided into eleven modules. During the first semester a common foundation (research skills, mathematical and physical basics, functioning and variability of the climate system, principles of economic and social sciences) is established. The second semester is designed to broaden interdisciplinary knowledge; students are free to design their own individual tailor-made study plan. In the last two semesters in-depth knowledge in one of the three tracks is acquired. Personalized course guidance and counseling is available throughout the studies. Participation in the orientation unit for first semester students at the beginning of October is strongly recommended.

Perspectives. A master degree in "Integrated Climate System Sciences" is the basis for a subsequent career in science and research, continuing with a doctorate program. At the same time, it qualifies for a career as climate science communicator in international organizations, global enterprises and agencies.

All courses listed in this handbook will be given in English and are in principle open for students of related M.Sc. programs, dependent on capacities and schedule. Please contact the lecturer.

Please note that this handbook is not legally binding and does not substitute the class schedule for the current semester, which is available on the internet and informs on lecture times and places, as well as on other changes. Additional information on the course of studies, credit points, and grading can be found in the **SICSS Handbook for M.Sc. Students**.

Contacts

School of Integrated Climate System Sciences, SICSS

www.sicss.de

Prof. Dr. Annette Eschenbach (Head)

Track-Coordinator **Physics**:	Prof Dr. Carsten Eden
Track-Coordinator **Biogeochemistry**:	Prof. Dr. Matthias Hort
Track-Coordinator **Economic and Social Sciences**:	Prof. Dr. Hermann Held

SICSS Office

Dr. Ingo Harms (Office Head)
Katja Grannis (MSc Coordinator)

Email: sicss@uni-hamburg.de
Tel.: +49 40 42838 7597
Universität Hamburg
Grindelberg 5-7
D-20144 Hamburg
Germany

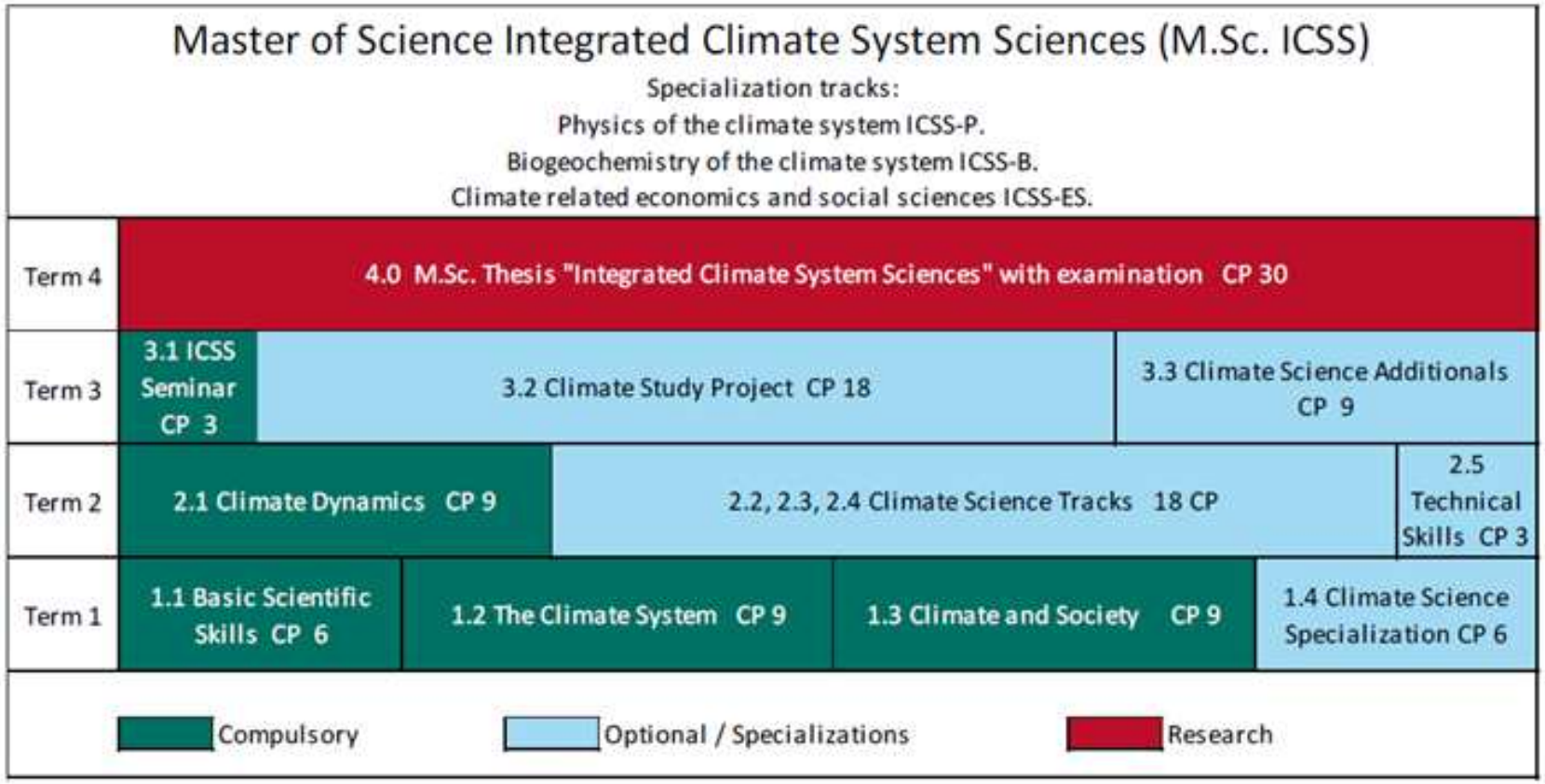
M.Sc. ICSS Examination Board (Prüfungsausschuss)

Prof. Dr. Carsten Eden (Chair),
Prof. Dr. Hermann Held, Prof. Dr. Matthias Hort (Professorial Members),
Dr. Simone Rödder, Dr. Frank Lunkeit (Scientist Representatives)
Rebecca Fröse, Aman Malik (Student Representatives)

Office of Academic Affairs for Earth Sciences (Studienbüro Geowissenschaften)

Dr. Ulrike Seiler (Office Head, STiNE Modelling)

Fakultät für Mathematik, Informatik und Naturwissenschaften,
Universität Hamburg
Geomatikum, 12. Stock
Bundesstraße 55
20146 Hamburg
Email: studienbuero@geowiss.uni-hamburg.de


Master of Science Integrated Climate System Sciences (M.Sc. ICSS)
Specialization tracks:
Physics of the climate system ICSS-P.
Biogeochemistry of the climate system ICSS-B.
Climate related economics and social sciences ICSS-ES.
Term 4
4.0 M.Sc. Thesis "Integrated Climate System Sciences" with examination CP 30
Term 3
3.1 ICSS Seminar CP 3
3.2 Climate Study Project CP 18
3.3 Climate Science Additionals CP 9
Term 2
2.1 Climate Dynamics CP 9
2.2, 2.3, 2.4 Climate Science Tracks 18 CP
2.5 Technical Skills CP 3
Term 1
1.1 Basic Scientific Skills CP 6
1.2 The Climate System CP 9
1.3 Climate and Society CP 9
1.4 Climate Science Specialization CP 6
Compulsory
Optional / Specializations
Research

Contents

color coding: track independent physics biogeochemistry economic and social sciences

Semester 1: Winter Semester

Module Abbreviation	1.1 CLIBASICS	
Title	**Basic Scientific Skills**	
Learning Outcomes	Students have been introduced to the concept of integrated climate system sciences; they have learned the fundamentals of mathematics, statistics, numerics and physics that are necessary for climate research.	
Contents	Compulsory courses: 1.1.1 Basic Research Skills (NN) 1.1.2 Introduction to Statistics (Blender)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	See specific announcements for the individual courses	
Exam Framework	Type:	Joint module exam, as a rule: report. Deviations will be announced at the beginning of the courses.
	Requirements for Registration:	none
	Language:	English
	Duration/Size:	Maximum 5 pages
Credit Points	6	
Course Type and Usability	Compulsory for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule	
Semester	Semester 1 of M.Sc. ICSS; reference semester 1	
Frequency of Offer	Annually in the winter semester	
Duration	1 semester, including a one-week block course in the first week of the lectures.	
Module Coordinator	Head of SCISS	

Course Number	ICSS-M-1.1.1 (63-901)	
Title **Learning Outcomes**	**Basic Research Skills** Students have been introduced to the concept of integrated climate system sciences; they have learned the fundamentals of mathematics, statistics, numerics and physics that are necessary for climate research. Students are familiar with the various sources of scientific information, with the guidelines of scientific practice, and with getting an giving feedback.	
Contents	Lectures and discussions on the various climate system science disciplines and their integration, refresher lectures on mathematics, data analysis, mechanics, fluid dynamics and numerics, all with exercises. Methods of scientific literature search, communication (reports, presentations, poster, discussions), choosing a thesis topic.	
Educational Concept	Lectures (2 SWS), homework assignments	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	Experienced knowledge of a word processing or typesetting system	
Exam Framework	Type:	Joint module exam
	Requirements for registration:	passing of two written exams and 3 writing assignments
	Language:	English
	Duration/size:	
	Weight Factor for Module Grade:	50%
Credit Points	3	
Workload	Campus Study:	26 hours
	Self-study:	34 hours
	Exam Preparation:	30 hours
Course Type and Usability	Compulsory for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 1 of M.Sc. ICSS	
Frequency of Offer	Annually in the winter semester	
Duration	1 semester	
Module Coordinator	Head of SCISS	
Course Lecturer(s)	NN	
Literature	Material will be provided during the course.	

Course Number	ICSS-M-1.1.2 (63-902)	
Title **Learning Outcomes**	**Introduction to Statistics** Students know the basics of probability theory and the most important probability distribution functions. They are able to perform standard statistical analyses including hypothesis tests. The students are familiar with the basics of extreme value theory, time series analysis, and autoregressive processes.	
Contents	Probability theory, probability density functions, parameter estimation, hypothesis testing, extreme value statistics, analysis of time series, stochastic processes.	
Educational Concept	Lectures (2 SWS) including discussions, introduction to the statistical software R, practice in applications, problem solution in teams	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	Unix on a basic level	

Exam Framework	Type:	Joint module exam
	Requirements for registration:	regular and active participation
	Language:	English
	Duration/size:	
	Weight Factor for Module Grade:	50%
Credit Points	3	
Workload	Campus Study:	26 hours
	Self-study:	26 hours
	Exam Preparation:	38 hours

Course Type and Usability	Compulsory for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.
Semester	Semester 1 of M.Sc. ICSS
Frequency of Offer	Annually in the winter semester
Duration	1 semester
Module Coordinator	Head of SCISS
Course Lecturer(s)	R. Blender
Literature	Will be announced during the course

Module Abbreviation	1.2 CLISYS	
Title	**The Climate System**	
Learning Outcomes	Students are familiar with the fundamental components of the physical and biogeochemical aspects of the climate system.	
Contents	Compulsory courses: 1.2.1 Physics of the Climate System (Baehr) 1.2.2 Global Biogeochemical Cycles . . . (Hartmann, Kutzbach)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	See specific announcements for the individual courses	
Exam Framework	Type:	Joint module exam, as a rule: oral. Deviations will be announced at the beginning of the lectures.
	Requirements for Registration:	none
	Language:	English
	Duration/Size:	Maximum 60 minutes
Credit Points	9	
Course Type and Usability	Compulsory for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule	
Semester	Semester 1 of M.Sc. ICSS; reference semester 1	
Frequency of Offer	Annually in the winter semester	
Duration	1 semester	
Module Coordinator	Track Coordinator Physics, Track Coordinator Biogeochemistry	

Course Number	ICSS-M-1.2.1 (63-904)	
Title **Learning Outcomes**	**Physics of the Climate System** Students have a basic understanding of the meteorological and oceanographic processes relevant for the mean state and variability of the climate system.	
Contents	Description of oceanic and atmospheric mean state, and circulation. Ocean – atmosphere interaction. Radiation Balance. Global Energy Budget and Transports. Thermohaline Circulation. Climate Variability from Decadal to Paleoclimatic timescales. Observations and Modeling of the Climate System.	
Educational Concept	Lectures (2 SWS) and exercises (2 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	none	
Exam Framework	Type:	Joint module exam
	Requirements for registration:	successful completion of exercises handed out in class
	Language:	English
	Duration/size:	
	Weight Factor for Module Grade:	
Credit Points	4.5	
Workload	Campus Study:	52 hours
	Self-study:	52 hours
	Exam Preparation:	31 hours
Course Type and Usability	Compulsory for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 1 of M.Sc. ICSS	
Frequency of Offer	Annually in the winter semester	
Duration	1 semester	
Module Coordinator	Track Coordinator Physics, Track Coordinator Biogeochemistry	
Course Lecturer(s)	J. Baehr	
Literature	Will be announced during the course.	

Course Number	ICSS-M-1.2.2 (63-905)	
Title **Learning Outcomes**	**Global Biogeochemical Cycles and the Climate System** Students understand the processes controlling the major global cycles of biogeochemical matter between the atmosphere, ocean and land. The students know the interactions between biogeochemical processes and the climate system.	
Contents	Biogeochemical processes relevant on the global scale. This includes the explanation of hydrologic, atmospheric, extraterrestrial, geological, biological, and human causes environmental change on time scales of tens, thousands, and millions of years.	
Educational Concept	Lectures (3 SWS) and exercises (1 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	none	
Exam Framework	Type:	Joint module exam
	Requirements for registration:	successful completion of exercises handed out in class
	Language:	English
	Duration/size:	
	Weight Factor for Module Grade:	
Credit Points	4.5	
Workload	Campus Study:	52 hours
	Self-study:	52 hours
	Exam Preparation:	31 hours
Course Type and Usability	Compulsory for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule. Maximum number of participants: 30 with preference for ICSS students	
Semester	Semester 1 of M.Sc. ICSS	
Frequency of Offer	Annually in the winter semester	
Duration	1 semester	
Module Coordinator	Track Coordinator Physics, Track Coordinator Biogeochemistry	
Course Lecturer(s)	J. Hartmann, L. Kutzbach	
Literature	Will be announced during the course.	

Module Abbreviation	1.3 CLISOC	
Title	**Climate and Society**	
Learning Outcomes	Students are familiar with the economic and social science basics and are able to apply this knowledge to climate related problems.	
Contents	Compulsory courses: 1.3.1 Climate Policy Scenarios: Economics, Integrative Assessments and Negotiations (Held, Köhl, Mues, Wolf) 1.3.2 Human-Environment Interactions and Climate Change: Security and Sustainability (Scheffran, Schneider) 1.3.3 Introduction to Social Sciences and Climate Communication (Brüggemann, Rödder)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	See specific announcements for the individual courses	
Exam Framework	Type:	Joint module examination, written or oral. The specific type will be announced at the beginning of the lectures.
	Requirements for Registration:	Course specific
	Language:	English
	Duration/Size:	maximum 120 minutes (written), 45 minutes (oral)
Credit Points	9	
Course Type and Usability	Compulsory for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule	
Semester	Semester 1 of M.Sc. ICSS; reference semester 1	
Frequency of Offer	Annually in the winter semester	
Duration	1 semester	
Module Coordinator	Track Coordinator Economic and Social Sciences	

Course Number	ICSS-M-1.3.1 (63-906)	
Title	**Climate Policy Scenarios: Economics, Integrative Assessments and Negotiations**	
Learning Outcomes	Students have an overview on the economic foundation and evaluation of coupled climate-energy-economy scenarios, the inventory based determination of forest stocks and management scenarios aiming in-depth at one particular policy measure, and the structure and processes of intergovernmental negotiations.	
Contents	Principles of economic welfare theory such as the concept of utility functions, social preferences and social planner, fundamental theorems in welfare economics, types of market failure; climate-target oriented integrated assessment, derivation of costs of policy interventions; based on the IPCC Guidelines on AFOLU (Agriculture, Forestry and Other Land Use), GHG reporting within the UNFCCC process. This will be done by the example of negotiations on the crediting of GHG mitigation measures in the forestry sector and the forest based industries.	
Educational Concept	Interactive Lectures (1 SWS, October - December) and subsequent block seminar (1 SWS, March)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	none	
Exam Framework	Type:	Written exam
	Requirements for registration:	Participation in block seminar
	Language:	English
	Duration/size:	
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	28 hours
	Self-study:	32hours
	Exam Preparation:	30 hours
Course Type and Usability	Compulsory for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 1 of M.Sc. ICSS	
Frequency of Offer	Annually in the winter semester	
Duration	1 semester	
Module Coordinator	Track Coordinator Economic and Social Sciences	
Course Lecturer(s)	H. Held, M. Köhl, V. Mues, A. Wolf	
Literature	Climate Change 2014 - Synthesis Report - Summary for Policymakers; IPCC Guidelines for National Greenhouse Gas Inventories (2006)	

Course Number	ICSS-M-1.3.2 (63-907)	
Title	**Human-Environment Interactions and Climate Change: Security and Sustainability**	
Learning Outcomes	Students have a fundamental understanding of human-environment interactions, are able to assess the societal impacts and conflicts of climate change and know the conceptual, normative and theoretical foundations of security and sustainability of resource use and public goods.	
Contents	Based on a framework of human-environment interactions in the Anthropocene, the complex relationship between climate change and socio-economic systems is assessed, with a focus on the security and sustainability dimensions. Factors and conditions of environmental change and resource conflicts are critically discussed, with a focus on the debate on climate change and human security, including water scarcity, food insecurity, flood and storm disasters and environmental migration in regional hot spots. The role of sustainable development in stabilizing human-environment interactions is discussed. Starting with definitions and classifications of the sustainability concept, ethical schools and normative values are introduced as well as the role of market prices and non-market services; internalization of externalities and public goods. Historical and recent perspectives and development in security and sustainability are presented.	
Educational Concept	Lectures (2 SWS) with homework assignments	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	none	
Exam Framework	Type:	Written/oral examination
	Requirements for registration:	Homework assignments
	Language:	English
	Duration/size:	
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	28 hours
	Self-study:	32 hours
	Exam Preparation:	30 hours
Course Type and Usability	Compulsory for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 1 of M.Sc. ICSS	
Frequency of Offer	Annually in the winter semester	
Duration	1 semester	

Module Coordinator	Track Coordinator Economic and Social Sciences
Course Lecturer(s)	J. Scheffran, U. Schneider
Literature	Will be announced during the course.

Course Number	ICSS-M-1.3.3 (63-908)	
Title **Learning Outcomes**	**Introduction to Social Sciences and Climate Communication** Students have acquired an understanding of (a) the place of the social sciences within science, (b) key social science concepts in their application to science and (c) the role and dynamics of public and media communication about climate change, climate policy and climate science.	
Contents	This course clarifies the place of the social sciences within science in comparison to the natural sciences. It introduces key social science concepts such as social roles, norms, and organisation. The course will use the case of climate change communication as one particularly relevant example of science communication to present and discuss both, the logics of the mass media and the study of the interplay of scientists, journalists and other actors in public debates about climate change. A cross-cutting theme will be to introduce social-scientific reasoning and how this can contribute to an integrated study of climate change.	
Educational Concept	Interactive Lectures (2 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	none	
Exam Framework	Type:	Oral/Written report
	Requirements for registration:	1 research essay and 1 short oral presentation incl. handout
	Language:	English
	Duration/size:	2 Assignments, 1500 words for the essay, 15 min presentation
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	26 hours
	Self-study:	26 hours
	Exam Preparation:	38 hours
Course Type and Usability	Compulsory for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 1 of M.Sc. ICSS	
Frequency of Offer	Annually in the winter semester	
Duration	1 semester	
Module Coordinator	Track Coordinator Economic and Social Sciences	
Course Lecturer(s)	M. Brüggemann, S. Rödder	
Literature	Will be announced during the course.	

Module Abbreviation	1.4 CLISPEC	
Title	**Climate Science Specialization**	
Learning Outcomes	Students have gained disciplinary knowledge in two special disciplines of the three tracks of climate science.	
Contents	2 courses have to be chosen: 1.4.1 Introduction to Numerical Approaches (Behrens) 1.4.2 Sea Ice (Kaleschke) 1.4.3 Atmospheric Circulation Systems: Part I (Borth) 1.4.4 Chemistry of Natural Waters (Hartmann) 1.4.5 Aerosols (Langmann) 1.4.6 The Role of Biota in the Climate System (Hense) 1.4.7 Introduction to Social Sciences' Methods (Brüggemann, Rödder)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	See specific announcements for the individual courses	
Exam Framework	Type:	Course specific exams: Written or oral exam, or oral or written report; overall test or component testing. The specific type will be announced at the beginning of the courses. The grades will be averaged.
	Requirements for Registration:	Course specific
	Language:	English
	Duration/Size:	maximum 90 minutes (written), 60 minutes (oral), 15 pages (written), 20 minutes (presentation)
Credit Points	6	
Course Type and Usability	Compulsory for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule	
Semester	Semester 1 of M.Sc. ICSS; reference semester 1	
Frequency of Offer	Annually in the winter semester	
Duration	1 semester	
Module Coordinator	Track Coordinators	

Course Number	ICSS-M-1.4.1 (63-911)	
Title	**Introduction to Numerical Approaches**	
Learning Outcomes	Students are familiar with the fundamentals of numerical approaches used in climate models. They know the underlying basic equations, the principle of numerical discretization and understand the uncertainties of climate models. They know how to implement numerical methods in prototypical software.	
Contents	Introduction to numerical methods and concepts of accuracy/ uncertainty evaluation: · introduction to numerical methods, floating point numbers, condition and stability, · solution of linear systems, · interpolation and approximation, · discretization of differential equations (finite differences), · efficiency, · finite differences, · programming introduction in MATLAB scripting.	
Educational Concept	Lectures (2 SWS) practicals (1 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	Knowledge of linear algebra, calculus and basic knowledge of computer usage, including basic programming knowledge	
Exam Framework	Type:	will be announced at the beginning of the course
	Requirements for registration:	active participation
	Language:	English
	Duration/size:	
	Weight Factor for Module Grade:	50%
Credit Points	3	
Workload	Campus Study:	39 hours
	Self-study:	21 hours
	Exam Preparation:	30 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 1 of M.Sc. ICSS	
Frequency of Offer	Annually in the winter semester	
Duration	1 semester	
Module Coordinator	Track Coordinators	
Course Lecturer(s)	J. Behrens	
Literature	Will be announced during the course.	

Course Number	ICSS-M-1.4.2 (63-755)	
Title	**Sea Ice**	
Learning Outcomes	Students know the physical basics of sea ice and about the role of sea ice in the climate system.	
Contents	Sea ice phenomenology and nomenclature; sea ice phase diagram; growth and melt of sea ice; surface heat balance; interaction with the ocean and the atmosphere; electromagnetic properties; measurement techniques; sea ice climatology.	
Educational Concept	Lectures and practical training (2 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	Linear algebra, calculus and basic knowledge of computer usage, including basic programming knowledge	
Exam Framework	Type:	will be announced at the beginning of the course
	Requirements for registration:	active participation
	Language:	English
	Duration/size:	
	Weight Factor for Module Grade:	50%
Credit Points	3	
Workload	Campus Study:	26 hours
	Self-study:	34 hours
	Exam Preparation:	30 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 1 of M.Sc. ICSS	
Frequency of Offer	Annually in the winter semester	
Duration	1 semester	
Module Coordinator	Track Coordinators	
Course Lecturer(s)	L. Kaleschke	
Literature	Will be announced during the course.	

Course Number	ICSS-M-1.4.3 (63-916)	
Title **Learning Outcomes**	**Atmospheric Circulation Systems: Part I** Students have an overview of basic physical concepts and processes explaining the structure and dynamics of planetary atmospheres, as well as a deeper understanding of selected examples.	
Contents	Important topics are: atmospheric environment, composition and structure; moist thermodynamics and the fluid parcel concept; circulation systems (waves, vortices and turbulence) in simple idealized atmospheres.	
Educational Concept	Lectures including discussions (2 SWS); exercises and worked examples (1 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	none	
Exam Framework	Type:	oral
	Requirements for registration:	active participation
	Language:	English
	Duration/size:	20 minutes
	Weight Factor for Module Grade:	50%
Credit Points	3	
Workload	Campus Study:	39 hours
	Self-study:	21 hours
	Exam Preparation:	30 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 1 of M.Sc. ICSS	
Frequency of Offer	Annually in the winter semester	
Duration	1 semester	
Module Coordinator	Track Coordinators	
Course Lecturer(s)	H. Borth	
Literature	Will be announced during the course.	

Course Number	ICSS-M-1.4.4 (63-357)	
Title	**Chemistry of Natural Waters**	
Learning Outcomes	Students know about important processes that control the chemical composition of natural waters (surface waters and groundwaters).	
Contents	Basic hydrochemical background knowledge, including equilibrium thermodynamics, activity-concentration relationships, the carbonate system and pH control on the composition of waters, basic knowledge about clay minerals and cation exchange, organic compounds in natural waters, redox equilibria, redox conditions in natural waters, kinetics, weathering and water chemistry. The approach is to combine background theory (e.g. thermodynamics, carbonate system (CO_2), dissolution/precipitation of matter, physics of water-air gas exchange, etc.) with case studies from the literature.	
Educational Concept	Lectures (2 SWS). Discussion of representative examples	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	Good knowledge of natural sciences.	
Exam Framework	Type:	will be announced at the beginning of the course
	Requirements for registration:	active participation
	Language:	English
	Duration/size:	
	Weight Factor for Module Grade:	50%
Credit Points	3	
Workload	Campus Study:	26 hours
	Self-study:	42 hours
	Exam Preparation:	22 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule. Maximum number of participants: 25	
Semester	Semester 1 of M.Sc. ICSS	
Frequency of Offer	Annually in the winter semester	
Duration	1 semester	
Module Coordinator	Track Coordinators	
Course Lecturer(s)	J. Hartmann	
Literature	Will be announced during the course.	

Course Number	ICSS-M-1.4.5 (63-912)	
Title	**Aerosols**	
Learning Outcomes	Students know the role of aerosols in the climate system.	
Contents	Aerosol sources and formation processes. Characterization of atmospheric aerosols. Aerosol modification in the atmosphere. Aerosol impact on climate. Spatial and temporal variations of aerosols in the climate system.	
Educational Concept	Lectures, seminar, exercises (2 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	none	
Exam Framework	Type:	will be announced at the beginning of the course
	Requirements for registration:	active participation
	Language:	English
	Duration/size:	
	Weight Factor for Module Grade:	50%
Credit Points	3	
Workload	Campus Study:	26 hours
	Self-study:	48 hours
	Exam Preparation:	16 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 1 of M.Sc. ICSS	
Frequency of Offer	Annually in the winter semester	
Duration	1 semester	
Module Coordinator	Track Coordinators	
Course Lecturer(s)	B. Langmann	
Literature	Will be announced during the course.	

Course Number	ICSS-M-1.4.6 (63-914)	
Title **Learning Outcomes**	**The Role of Biota in the Climate System** Students are able to understand biologically-driven, climate-relevant processes and mechanisms. They are able to identify and describe feedback loops in which the biota plays an important role.	
Contents	In this lecture biological processes involved in climate-relevant mechanisms are explained. Biologically induced changes of different Earth System components (Hydrosphere, Atmosphere, Cryosphere and Lithosphere) are presented and the mechanisms involved in climate feedback loops are discussed. Examples of the different feedback loops are provided from both the marine and terrestrial systems.	
Educational Concept	Lectures (2 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	none	

Exam Framework	Type:	will be announced at the beginning of the course
	Requirements for registration:	active participation
	Language:	English
	Duration/size:	
	Weight Factor for Module Grade:	50%
Credit Points	3	
Workload	Campus Study:	26 hours
	Self-study:	48 hours
	Exam Preparation:	16 hours

Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.
Semester	Semester 1 of M.Sc. ICSS
Frequency of Offer	Annually in the winter semester
Duration	1 semester
Module Coordinator	Track Coordinators
Course Lecturer(s)	I. Hense
Literature	Will be announced during the course.

Course Number	ICSS-M-1.4.7 (63-910)	
Title **Learning Outcomes**	**Introduction to Social Sciences' Methods** Students are familiar with the most common quantitative and qualitative research methodologies in the social sciences: interview, survey, participant observation and content analysis.	
Contents	The aim of this course is to introduce students with a background in natural sciences or geography to relevant quantitative and qualitative research methodologies in the social sciences: interview, survey, participant observation and content analysis. The course consists of short interactive lectures and research exercises in which the students pursue their own research questions to gain some practical experience in data acquisition and analysis in the social sciences. The course will be held in several block lectures in the second half of the winter term.	
Educational Concept	Interactive Lecture with practical applications of methods (2 SWS)	
Language	English	
Formal Requirements for Participation	Concurrent participation in the course *Introduction to the social sciences (Course 1.3.3)*	
Recommended Prerequisites	none	
Exam Framework	Type:	Oral/Written report
	Requirements for registration:	1 research report and 1 short oral presentation incl. handout
	Language:	English
	Duration/size:	Assignments, 1500 words for the report, 20 min presentation
	Weight Factor for Module Grade:	50%
Credit Points	3	
Workload	Campus Study:	26 hours
	Self-study:	26 hours
	Exam Preparation:	38 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 1 of M.Sc. ICSS	
Frequency of Offer	Annually in the winter semester	
Duration	1 semester	
Module Coordinator	Track Coordinators	
Course Lecturer(s)	M. Brüggemann, S. Rödder	
Literature	Will be announced during the course.	

Semester 2: Summer Semester

Module Abbreviation	2.1 CLIDYN	
Title	**Climate Dynamics**	
Learning Outcomes	Students have gained in-depth knowledge in the dynamics of geophysical fluids, in particular the variability on various time scales.	
Contents	Compulsory courses: 2.1.1 Climate Dynamics (Marotzke) 2.1.2 Dynamical Palaeoclimatology (Claussen) 2.1.3 Scales in the Climate System (Baehr, Behrens, Brüggemann, Frisius, Hartmann, Hense, Kaleschke, Kutzbach, Rödder, Scheffran)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	See specific announcements for the individual courses	
Exam Framework	Type:	Joint module exam, as a rule: written exam. Deviations will be announced at the beginning of the courses
	Requirements for Registration:	Course specific
	Language:	English
	Duration/Size:	maximum 120 minutes (written) or 45 minutes (oral)
Credit Points	9	
Course Type and Usability	Compulsory for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule	
Semester	Semester 2 of M.Sc. ICSS; reference semester 2	
Frequency of Offer	Annually in the summer semester	
Duration	1 semester	
Module Coordinator	Track Coordinator Physics	

Course Number	ICSS-M-2.1.1 (63-879)	
Title **Learning Outcomes**	**Climate Dynamics** Students have a thorough understanding of the theoretical basics of climate dynamics, and know the art and science of constructing conceptual models of the climate system.	
Contents	Concepts and models are introduced that help us to understand fundamental aspects of the earth's climate, such as global mean temperature, global-scale temperature differences, and what might cause these to vary on timescales of decades and longer. Particular emphasis will be placed on oceanic and coupled ocean-atmosphere processes. While we cover observed elements of the climate system and a hierarchy of models ranging from the simplest models to general circulation models, the focus will be on the art and science of constructing simplified models that help us obtain conceptual understanding. Discussing what is not understood, and hence identifying areas of current and future research, will be a crucial element of the course.	
Educational Concept	Lectures (2 SWS), homework assignments	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	Basic calculus and differential equations; some introduction to atmospheric or oceanic science	
Exam Framework	Type:	Joint module exam
	Requirements for registration:	An overall grade of at least 50% in homework assignments
	Language:	English
	Duration/size:	
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	24 hours
	Self-study:	36 hours
	Exam Preparation:	30 hours
Course Type and Usability	Compulsory for M.Sc. ICSS; open for students of related M.Sc. and Ph.D. programs, dependent on capacities and schedule.	
Semester	Semester 2 of M.Sc. ICSS	
Frequency of Offer	Annually in the summer semester	
Duration	1 semester	
Module Coordinator	Track Coordinator Physics	
Course Lecturer(s)	J. Marotzke	
Literature	Will be announced during the course.	

Course Number	ICSS-M-2.1.2 (63-863)	
Title **Learning Outcomes**	**Dynamical Palaeoclimatology** Students know the distinction between externally forced climate variability and internal climate variability at time scales of centuries and longer.	
Contents	A brief overview of climate variations and climate change since the beginning of Earth some 4.6 billion years ago is given. Climate reconstructions from paleo records are physically interpreted by using conceptual and comprehensive climate system models. Precambrian: the snowball earth. Phanerozoic: effects of long-term plate tectonics and development of the biosphere. Mesozoic and early Cenozoic: greenhouse climate and Tertiary cooling. Quaternary: Ice ages, Milankovich cycles. Pleistocene: sub-Milankovich cycles. Holocene: interglacial climate, little ice age. Anthropocene: external greenhouse gas emissions, land-cover change.	
Educational Concept	Lectures (2 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	none	
Exam Framework	Type:	Joint module exam
	Requirements for registration:	Regular and active participation
	Language:	English
	Duration/size:	
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	28 hours
	Self-study:	42 hours
	Exam Preparation:	20 hours
Course Type and Usability	Compulsory for M.Sc. ICSS; open for students of related M.Sc. and Ph.D. programs, dependent on capacities and schedule.	
Semester	Semester 2 of M.Sc. ICSS	
Frequency of Offer	Annually in the summer semester	
Duration	1 semester	
Module Coordinator	Track Coordinator Physics	
Course Lecturer(s)	M. Claussen	
Literature	Will be announced during the course.	

Course Number	ICSS-M-2.1.3 (63-921)	
Title **Learning Outcomes**	**Scales in the Climate System** Students are familiar with the different temporal and spatial scales and coupling strengths of physical, biogeochemical as well as socio-economical processes within the climate system. They are knowledgeable about the computational means to represent such scale interaction in simulations.	
Contents	Processes on temporal scales from less than 1 day to greater than 1000 years as well as spatial scales from local to global will be considered. An additional focus will be on coupling strength of physical, biogeochemical as well as socio-economical processes. Modeling and computational methods for scale interaction and coupling will be discussed.	
Educational Concept	Seminar (2 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	none	
Exam Framework	Type:	Joint module exam
	Requirements for registration:	80% participation at the seminar
	Language:	English
	Duration/size:	
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	28 hours
	Self-study:	62 hours
	Exam Preparation:	0 hours
Course Type and Usability	Compulsory for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 2 of M.Sc. ICSS	
Frequency of Offer	Annually in the summer semester	
Duration	1 semester	
Module Coordinator	Track Coordinator Physics	
Course Lecturer(s)	J. Baehr, J. Behrens, M. Brüggemann, T. Frisius, J. Hartmann, I. Hense, L. Kaleschke, L. Kutzbach, S. Rödder, J. Scheffran	
Literature	Will be announced during the course.	

Module Abbreviation	2.2 CLITRAC-P	
Title	**Climate Science Track Physics**	
Learning Outcomes	Students have gained detailed experience and are specialized in questions, methods and results in physical climate sciences.	
Contents	A maximum of 9 CP from the following courses will be accredited (contributing to the total of 18 CP that have to be accumulated out of module 2.2, 2.3 and 2.4): 2.2.1 Waves and Turbulence (Eden) 2.2.2 Waves and Turbulence Practicals (Czeschel, Griesel) 2.2.3 Advanced Numerical Methods . . . (Behrens) 2.2.4 Concepts of Climate Modeling (Baehr) 2.2.5 Conceptual Models of Complex Systems: Development, Application and Analysis (Frisius) 2.2.6 Weather and Climate Risk (Franzke, Lucarini) 2.2.7 Atmospheric Circulation Systems: Part II (Borth)	
Language	English	
Formal Requirements for Participation	See specific announcements for the individual courses	
Recommended Prerequisites	See specific announcements for the individual courses	
Exam Framework	Type:	Joint module exam, as a rule: oral. Deviations will be announced at the beginning of the courses
	Requirements for Registration:	Course specific
	Language:	English
	Duration/Size:	maximum 45 minutes (oral)
Credit Points	3, 6, or 9 are possible	
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule	
Semester	Semester 2 of M.Sc. ICSS; reference semester 2	
Frequency of Offer	Annually in the summer semester	
Duration	1 semester	
Module Coordinator	Track Coordinator Physics	

Course Number	ICSS-M-2.2.1 (63-732)	
Title	**Waves and Turbulence**	
Learning Outcomes	Students will have obtained knowledge about the physical theoretical foundations of the spectrum of variability in the ocean (from periodic processes to mesoscale eddies to turbulence). They understand the fundamental mechanisms, their mathematical description and their treatment in ocean general circulation models.	
Contents	Sound, internal and planetary waves, propagation in variable environment, instability of waves. Three- and two-dimensional turbulence, generation and dissipation, energy and enstrophy cascades, relationship between turbulence and mixing, parameterization of turbulence in models.	
Educational Concept	Lectures (4 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	none	
Exam Framework	Type:	Joint track exam
	Requirements for registration:	Active participation
	Language:	English
	Duration/size:	
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	56 hours
	Self-study:	14 hours
	Exam Preparation:	20 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 2 of M.Sc. ICSS	
Frequency of Offer	Annually in the summer semester	
Duration	1 semester	
Module Coordinator	Track Coordinator Physics	
Course Lecturer(s)	C. Eden	
Literature	Will be announced during the course.	

Course Number	ICSS-M-2.2.2 (63-733)	
Title	**Waves and Turbulence Practicals**	
Learning Outcomes	Students will have obtained in depth practical experience of solving common theoretical problems.They will understand the fundamental mechanisms and the mathematical description of ocean theory. They will gain experience about ocean general circulation models.	
Contents	Various wave solutions and their practical application of internal and planetary waves. Common problems of linear stability analysis and instability of waves. Mixing and parameterizations in ocean models.	
Educational Concept	Exercises (2 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	none	
Exam Framework	Type:	Joint track exam
	Requirements for registration:	Active participation
	Language:	English
	Duration/size:	
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	28 hours
	Self-study:	48 hours
	Exam Preparation:	14 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 2 of M.Sc. ICSS	
Frequency of Offer	Annually in the summer semester	
Duration	1 semester	
Module Coordinator	Track Coordinator Physics	
Course Lecturer(s)	L. Czeschel, A. Griesel	
Literature	Will be announced during the course.	

Course Number	ICSS-M-2.2.3 (63-938)	
Title **Learning Outcomes**	**Advanced Numerical Methods for Climate Modeling** Students have gained insight in advanced numerical methods for climate modeling, especially for conservation laws, efficient parallel solvers for large linear systems of equations, multi-level methods, etc.	
Contents	Introduction to numerical methods for the implementation of conservation laws: · introduction to structure of conservation laws, · finite volume methods, discontinuous Galerkin methods, finite element methods, · advanced time integration schemes, · issues in high performance computing. Parallel solution of large systems of linear equations: · introduction to parallel architectures and HPC systems, · iterative solution of large systems of equations: Krylov subspace methods, multi-level methods, · efficient pre-conditioners.	
Educational Concept	Lectures, practical exercises (2 SWS)	
Language	English	
Formal Requirements for Participation	Regular participation in the course *Introduction to Numerical Approaches*.	
Recommended Prerequisites	Knowledge of mathematical concepts in ordinary and partial differential equations, basic knowledge of theoretical meteorology and/or oceanography	
Exam Framework	Type:	Joint track exam
	Requirements for registration:	Active participation
	Language:	English
	Duration/size:	
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	28 hours
	Self-study:	42 hours
	Exam Preparation:	20 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 2 of M.Sc. ICSS	
Frequency of Offer	Annually in the summer semester	
Duration	1 semester	
Module Coordinator	Track Coordinator Physics	
Course Lecturer(s)	J. Behrens	
Literature	Will be announced during the course.	

Course Number	ICSS-M-2.2.4 (63-937)	
Title **Learning Outcomes**	**Concepts of Climate Modeling** Students will have a basic understanding of the advantages and limitations of climate models, and their use to enhance our understanding of the climate system.	
Contents	Investigate the use of (components of) climate models. The analysis will be guided by questions posed by the instructor as well as the students themselves.	
Educational Concept	Lectures and tutorials (2 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	none	
Exam Framework	Type:	Joint track exam
	Requirements for registration:	Active participation
	Language:	English
	Duration/size:	
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	28 hours
	Self-study:	32 hours
	Exam Preparation:	30 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 2 of M.Sc. ICSS	
Frequency of Offer	Annually in the summer semester	
Duration	1 semester	
Module Coordinator	Track Coordinator Physics	
Course Lecturer(s)	J. Baehr	
Literature	Will be announced during the course.	

Course Number	ICSS-M-2.2.5 (63-939)	
Title	**Conceptual Models of Complex Systems: Development, Application and Analysis**	
Learning Outcomes	Students have gained skills in developing conceptual mathematical models of complex systems. The students will be able to code such models, to perform numerical simulations and to carry out dynamical system analysis. The approach is multidisciplinary and, therefore, the student will be able to apply the techniques to the numerous fields within integrated climate system sciences.	
Contents	Introduction to model development, simulation and dynamical system analysis focusing on conceptual models of complex systems for a broad spectrum of disciplines(physics, climate, ecosystems, society and resources). Models as dynamical systems, i.e., a closed set of ordinary differential equations. Model analyses (role of initial conditions, trajectories in phase space, steady states and limit cycles, bifurcations, attractors, stability, Lyapunov exponents, regime diagrams). Simple models are presented, e.g., the socioeconomic model World-2 is introduced that predicts possible paths of societies' future.	
Educational Concept	Lectures and practical training (3 SWS).	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	Basic knowledge of mathematics and physics	

Exam Framework	Type:	Joint track exam
	Requirements for registration:	Active participation
	Language:	English
	Duration/size:	
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	42 hours
	Self-study:	28 hours
	Exam Preparation:	20 hours

Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.
Semester	Semester 2 of M.Sc. ICSS
Frequency of Offer	Annually in the summer semester
Duration	1 semester
Module Coordinator	Track Coordinator Physics
Course Lecturer(s)	T. Frisius
Literature	Will be announced during the course.

Course Number	ICSS-M-2.2.6 (63-932)	
Title	**Weather and Climate Risk**	
Learning Outcomes	Students have learned the fundamental physics of extreme weather and climate events. They have an understanding of the socio-economic aspects of weather and climate risks, especially the insurance and catastrophe modeling sectors. Students will learn about best practice how to communicate weather and climate risks to different stakeholders and the public.	
Contents	The course covers the physics of extreme weather and climate events, the basics of the insurance and catastrophe modeling sectors and weather derivatives through illustrative examples and case studies. In addition, the course covers risk communication.	
Educational Concept	Lectures (2 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	Knowledge of basic meteorology and climate dynamics	
Exam Framework	Type:	Joint track exam
	Requirements for registration:	active participation
	Language:	English
	Duration/size:	
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	28 hours
	Self-study:	42 hours
	Exam Preparation:	20 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. and Ph.D. programs, dependent on capacities and schedule.	
Semester	Semester 2 of M.Sc. ICSS	
Frequency of Offer	Annually in the summer semester	
Duration	1 semester	
Module Coordinator	Track Coordinator Physics	
Course Lecturer(s)	C. Franzke, V. Lucarini	
Literature	Will be announced during the course.	

Course Number	ICSS-M-2.2.7 (63-???)	
Title	**Atmospheric Circulation Systems: Part II**	
Learning Outcomes	Students have gained a deeper insight into selected atmospheric circulation systems and acquire basic knowledge on global atmospheric circulation modeling.	
Contents	Important topics are: moist entropy and tropical circulation systems; potential vorticity and mid-latitude dynamics; atmospheric global circulation modeling; atmospheric transport	
Educational Concept	Lectures including discussions (2 SWS); exercises and worked examples (1 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	Participation in the course *Atmospheric Circulation Systems: Part I*	
Exam Framework	Type:	Joint track exam
	Requirements for registration:	active participation
	Language:	English
	Duration/size:	
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	39 hours
	Self-study:	21 hours
	Exam Preparation:	30 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 2 of M.Sc. ICSS	
Frequency of Offer	Annually in the summer semester	
Duration	1 semester	
Module Coordinator	Track Coordinator Physics	
Course Lecturer(s)	H. Borth	
Literature	Will be announced during the course.	

Module Abbreviation	2.3 CLITRAC-B	
Title	**Climate Science Track Biogeochemistry**	
Learning Outcomes	Students have gained detailed experience and are specialized in questions, methods and results in biogeochemical climate sciences.	
Contents	A maximum of 9 CP from the following courses will be accredited (contributing to the total of 18 CP that have to be accumulated out of module 2.2, 2.3 and 2.4): 2.3.1 Land-Ocean Transport . . . (Hartmann) 2.3.2 Soil, Water and Vegetation. . . (Kutzbach, Knoblauch) 2.3.3 Dynamics of Marine Ecosystems (Hense) 2.3.4 Selected Topics of Marine Ecosystem Dynamics (Hense) 2.3.5 Soils and Land Use of Wetlands (Pfeiffer, Kutzbach) 2.3.6 Field Course on Soil-Atm. Coupling (Kutzbach, Knoblauch) 2.3.7 History of the human footprint on the Earth system (Pongratz, Reick)	
Language	English	
Formal Requirements for Participation	See specific announcements for the individual courses	
Recommended Prerequisites	See specific announcements for the individual courses	
Exam Framework	Type:	Joint module exam, as a rule: oral. Deviations will be announced at the beginning of the courses
	Requirements for Registration:	Course specific
	Language:	English
	Duration/Size:	maximum 45 minutes (oral)
Credit Points	3, 6, or 9 are possible	
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule	
Semester	Semester 2 of M.Sc. ICSS; reference semester 2	
Frequency of Offer	Annually in the summer semester	
Duration	1 semester	
Module Coordinator	Track Coordinator Biogeochemistry	

Course Number	ICSS-M-2.3.1 (63-941)	
Title	**Land-Ocean Transport of Biogeochemical Matter**	
Learning Outcomes	Students know about the processes that steer lateral transport of biogeochemical matter (e.g. C, Si, N, P) from land to the ocean. They understand processes that lead to mobilization of matter from the terrestrial land system into the fluvial system, transformation processes of the biogeochemical matrix in the water during transport to the coastal zones. Students know about the role of lateral matter transports in the climate system.	
Contents	Mobilization of biogeochemical matter from the terrestrial land system into river systems; transformation of the biogeochemical matrix during transport including photosynthesis, respiration of organic matter and hydrochemical dissolution of matter; water-air gas exchange (CO_2, CH_4) in context of biogeochemical processes; coastal zones as filters of transported matter to the ocean; the role of the land-ocean fluxes in context of global cycles of biogeochemical matter.	
Educational Concept	Lectures (2 SWS) including discussion of case studies	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	Regular participation in the course *Global Biogeochemical Cycles and the Climate System*.	
Exam Framework	Type:	Joint track exam
	Requirements for registration:	Active participation
	Language:	English
	Duration/size:	
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	28 hours
	Self-study:	40 hours
	Exam Preparation:	22 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 2 of M.Sc. ICSS	
Frequency of Offer	Annually in the summer semester	
Duration	1 semester	
Module Coordinator	Track Coordinator Biogeochemistry	
Course Lecturer(s)	J. Hartmann	
Literature	Will be announced during the course.	

Course Number	ICSS-M-2.3.2 (63-313)	
Title	**Soil, Water and Vegetation Processes and Their Coupling to the Atmosphere**	
Learning Outcomes	Students have knowledge of the biogeochemical and biophysical processes in soils and the vegetation, and their interaction with the atmosphere. They will obtain a good scientific basis for both measurement- and model-based studies of the coupled processes of soils, vegetation and atmosphere.	
Contents	Atmospheric boundary layer characteristics, wind and turbulence mass and energy exchange; aeolian transport and deposition of elements; soil energy budget; soil water dynamics; plant-soil-microorganism interactions; soil organic matter processes, organic matter humification and mineralization, heterotrophic respiration; soil methane cycle: production, oxidation and soil-atmosphere transport mechanisms; lateral transport of carbon and nutrients; soil-vegetation-atmosphere water and carbon exchange processes, evapotranspiration, photosynthesis, autotrophic respiration; instrumentation for biometeorological measurements (e.g. closed chambers, eddy covariance method, isotope analyses).	
Educational Concept	Lectures with short group work exercises (2 SWS).	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	Basic knowledge of soil science and/or plant ecophysiology and/or meteorology	
Exam Framework	Type:	Joint track exam
	Requirements for registration:	Active participation in exercises
	Language:	English
	Duration/size:	
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	28 hours
	Self-study:	32 hours
	Exam Preparation:	30 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 2 of M.Sc. ICSS	
Frequency of Offer	Annually in the summer semester	
Duration	1 semester	
Module Coordinator	Track Coordinator Biogeochemistry	
Course Lecturer(s)	L. Kutzbach, C. Knoblauch	
Literature	Will be announced during the course	

Course Number	ICSS-M-2.3.3 (63-942)	
Title	**Dynamics of Marine Ecosystems**	
Learning Outcomes	Students are able to understand and interpret spatial and temporal distribution patterns of marine ecosystem variables. This includes time series and distribution maps of biological and physico- chemical variables in the ocean. The students are able to identify and describe the underlying processes leading to the variability in the biological fields.	
Contents	In this lecture the factors and processes regulating marine primary production and transfer to higher trophic levels are explained. The spatial and temporal distribution patterns and variability in biological, nutrient and physical fields in the ocean are presented and the interaction between the biota and its physico-chemical environment is discussed. Examples include coastal regions, upwelling systems, fronts and oligotrophic oceans.	
Educational Concept	Lectures (2 SWS)	
Language	English	
Formal Requirements for Participation	Regular participation in the lecture courses *Physics of the Climate System* and *Global Biogeochemical Cycles and the Climate System*	
Recommended Prerequisites	Basic knowledge of physical oceanography and biogeochemical cycles	
Exam Framework	Type:	Joint track exam
	Requirements for registration:	Active participation
	Language:	English
	Duration/size:	
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	28 hours
	Self-study:	45 hours
	Exam Preparation:	17 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 2 of M.Sc. ICSS	
Frequency of Offer	Annually in the summer semester	
Duration	1 semester	
Module Coordinator	Track Coordinator Biogeochemistry	
Course Lecturer(s)	I. Hense	
Literature	Will be announced during the course	

Course Number	ICSS-M-2.3.4 (63-943)	
Title **Learning Outcomes**	**Selected Topics of Marine Ecosystem Dynamics** Students are able to present scientific results from other people's work. They have become acquainted with state-of-the-art research topics in the field of biological oceanography/marine ecosystems. The students are able to identify the major gaps in current research.	
Contents	In this seminar topical papers from high-ranking peer reviewed journals in the field of biological oceanography and marine ecosystems are presented and discussed. The articles cover a wide range of topics and deal with recent advances made in research during the past five years.	
Educational Concept	Seminar (2 SWS)	
Language	English	
Formal Requirements for Participation	Concurrent participation in the course *Dynamics of Marine Ecosystems.*	
Recommended Prerequisites	Basic knowledge of physical oceanography and biogeochemical cycles	
Exam Framework	Type:	Joint track exam
	Requirements for registration:	>80% participation in the seminar
	Language:	English
	Duration/size:	
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	28 hours
	Self-study:	45 hours
	Exam Preparation:	17 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 2 of M.Sc. ICSS	
Frequency of Offer	Annually in the summer semester	
Duration	1 semester	
Module Coordinator	Track Coordinator Biogeochemistry	
Course Lecturer(s)	I. Hense	
Literature	Will be announced during the course	

Course Number	ICSS-M-2.3.5 (63-945)	
Title	**Soils and Land Use of Wetlands**	
Learning Outcomes	Students have gained knowledge about the genesis, properties and functions of hydromorphic soils of marshes and peatlands in the coastal lowlands of Northern Germany. They have developed their understanding of how landscape development, geomorphology, hydrology, and land use are interlinked with the diversity and distribution of wetland soils. The students are able to evaluate the ecological and economic functions of wetlands and their response to land use and climate changes.	
Contents	Landscape development of the coastal lowlands of Northern Germany; geologic processes during Pleistocene and Holocene; geomorphology of marshes and river floodplains; land use history, diking and agriculture; soils of tidal flats and different marsh types; soils and vegetation of bogs and fens; German, US and international soil classification systems; ecological and economic functions; impact of past and present land use and climatic changes.	
Educational Concept	3 full days of excursion and 0.5 day seminar, practical group-work (6-8 students each)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	Basic knowledge of soil science	

Exam Framework	Type:	Joint track exam
	Requirements for registration:	Active participation, field protocol (5 pages)
	Language:	English
	Duration/size:	
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	35 hours
	Self-study:	30 hours
	Exam Preparation:	25 hours

Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.
Semester	Semester 2 of M.Sc. ICSS
Frequency of Offer	Annually in the summer semester
Duration	Block course
Module Coordinator	Track Coordinator Biogeochemistry
Course Lecturer(s)	E.-M. Pfeiffer, L. Kutzbach
Literature	Will be announced during the course

Course Number	ICSS-M-2.3.6 (63-946)	
Title **Learning Outcomes**	**Field Course on Soil-Atmosphere Coupling** Students advance their experience with soil-scientific field measurement campaigns, gas flux measurements and data analysis for investigating soil-vegetation-atmosphere interactions.	
Contents	Soil-scientific survey and description of reference soil profiles, soil gas concentration profile measurements, closed-chamber approach to measure land-atmosphere fluxes of trace gases, flux calculation, basic statistical data analysis.	
Educational Concept	Field (2 full days) and laboratory practice (0.5 day) plus seminar (1 full day).	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	Basic knowledge about soil processes, e.g. through participation in course *Soil, water and vegetation processes and their coupling to the atmosphere*.	
Exam Framework	Type:	Joint track exam
	Requirements for registration:	Active participation, 80% presence at the seminar,
	Language:	English
	Duration/size:	
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	30 hours
	Self-study:	30 hours
	Exam Preparation:	30 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 2 of M.Sc. ICSS	
Frequency of Offer	Annually in the summer semester	
Duration	3-day block + 0.5-day block, both after the lecture period (or in the semester break) plus preparation meeting at beginning of semester	
Module Coordinator	Track Coordinator Biogeochemistry	
Course Lecturer(s)	L. Kutzbach, C. Knoblauch	
Literature	Literature recommendations will be given at the planning meeting.	

Course Number	ICSS-M-2.3.7 (63-947)	
Title	**History of the human footprint on the Earth system**	
Learning Outcomes	Students will have gained knowledge about the human impact on the Earth system from the viewpoint of multiple disciplines (in particular natural sciences, historical and socioeconomic aspects). They have improved essential academic skills by taking the lead on investigating and presenting scientific topics, by collaboration in small and large groups, and by developing methods for outreach.	
Contents	The history of human influence on climate and other Earth system components will be explored. Moving from the first use of fire to future climate engineering, topics covered include cultural collapses, the Anthropocene discussion, and resource limitations.	
Educational Concept	An interactive mix of lectures, discussions, and practical work. Students will collaboratively work on the course's topics, prepare scientific posters, and present them in a final poster session (2 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	Interest in interdisciplinary work, collaborative skills	
Exam Framework	Type:	joint track exam
	Requirements for registration:	regular and active participation
	Language:	English
	Duration/size:	
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	28 hours
	Self-study:	32 hours
	Exam Preparation:	30 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule	
Semester	Semester 2 of M.Sc. ICSS	
Frequency of Offer	Annually in the summer semester	
Duration	1 semester	
Module Coordinator	SICSS Track Coordinators	
Course Lecturer(s)	J. Pongratz, C. Reick	
Literature	Will be announced during the course	

Module Abbreviation	2.4 CLITRAC-ES	
Title	**Climate Science Track Economic and Social Sciences**	
Learning Outcomes	Students have gained detailed experience and are specialized in questions, methods and results in economic and social climate sciences.	
Contents	A maximum of 9 CP from the following courses will be accredited (contributing to the total of 18 CP that have to be accumulated out of module 2.2, 2.3 and 2.4): 2.4.1a Energy Landscape and Climate Policy (Scheffran) 2.4.1b Models of Human-Environment Interaction (Scheffran) 2.4.2 Estimating Sustainable Land Use (Schneider) 2.4.3 Agent-based Modelling – Theory and Applications in the Social Sciences (Scheffran, Hokamp) 2.4.4 Integrated Climate-Economic Modeling (Held)	
Language	English	
Formal Requirements for Participation	See specific announcements for the individual courses	
Recommended Prerequisites	See specific announcements for the individual courses	
Exam Framework	Type:	Joint module exam, as a rule: oral. Deviations will be announced at the beginning of the courses
	Requirements for Registration:	Course specific
	Language:	English
	Duration/Size:	maximum 45 minutes (oral)
Credit Points	3, 6, or 9 are possible	
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule	
Semester	Semester 2 of M.Sc. ICSS; reference semester 2	
Frequency of Offer	Annually in the summer semester	
Duration	1 semester	
Module Coordinator	Track Coordinator Economic and Social Sciences	

Course Number	ICSS-M-2.4.1a (63-951)	
Title **Learning Outcomes**	**Energy Landscape and Climate Policy** The students have an understanding of the key factors and patterns in energy landscapes and climate policy on national and international levels, and are able to assess different energy pathways according to multiple criteria and strategies.	
Contents	Introduction to geographic, socio-economic and political aspects of energy landscapes, resources and technologies, including fossil, nuclear and renewable energy systems. Different assessment dimensions will be covered: energy security and sustainability; environmental impacts and CO2-emissions from energy production; climate change mitigation and adaptation strategies; comparison of energy and climate policy regimes and institutions; energy transformation and governance mechanisms.	
Educational Concept	Lectures (2 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	none	
Exam Framework	Type:	Joint track exam
	Requirements for registration:	Active participation
	Language:	English
	Duration/size:	
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	28 hours
	Self-study:	32 hours
	Exam Preparation:	30 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 2 of M.Sc. ICSS	
Frequency of Offer	Every other year in the summer semester	
Duration	Block course	
Module Coordinator	Track Coordinator Economic and Social Sciences	
Course Lecturer(s)	J. Scheffran	
Literature	Will be announced during the course	

Course Number	ICSS-M-2.4.1b (63-???)	
Title	**Models of Human-Environment Interaction**	
Learning Outcomes	Students have achieved knowledge and basic skills about models and integrated frameworks of human-environment interaction, including major model types, computational means and software tools, and key phenomena at the intersection of human and natural systems.	
Contents	The lecture provides an introduction to models of human-environment interaction, relevant in integrative geography, complexity science, conflict research, climate and sustainability science. Overview of basic model types: dynamic systems and spatial models, statistical and probability models, complex adaptive systems and cellular automata, agent-based and network models, game theory, decision and optimization models, integrated assessment and world models. Instructive application areas will be used to demonstrate the relevance of models at the intersection of environmental and socio-economic systems, including climate change, energy, natural resources, sustainable development, environmental conflict and cooperation.	
Educational Concept	Lectures (2 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	none	
Exam Framework	Type:	Joint track exam
	Requirements for registration:	Active participation
	Language:	English
	Duration/size:	
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	28 hours
	Self-study:	32 hours
	Exam Preparation:	30 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 2 of M.Sc. ICSS	
Frequency of Offer	Every other year in the summer semester	
Duration	Block course	
Module Coordinator	Track Coordinator Economic and Social Sciences	
Course Lecturer(s)	J. Scheffran	
Literature	Will be announced during the course	

Course Number	ICSS-M-2.4.2 (63-952)	
Title **Learning Outcomes**	**Estimating Sustainability** Students have learned how to design, program, and apply an integrated assessment model for the investigation of sustainable land use pathways.	
Contents	Integrated agricultural sector analysis; Partial equilibrium modelling; Applied mathematical programming with GAMS (Numerical solution to constrained optimization problems); Environmental policy analysis (Internalization of ecosystem services); Weak and strong sustainability; Ecological guardrails; Dynamic optimization under uncertainty; Value of information.	
Educational Concept	Lectures (2 SWS) with many hands-on exercises in computer lab	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	Successful completion of the course *Introduction to GAMS*	
Exam Framework	Type:	Joint track exam
	Requirements for registration:	Active participation
	Language:	English
	Duration/size:	
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	28 hours
	Self-study:	32 hours
	Exam Preparation:	30 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 2 of M.Sc. ICSS	
Frequency of Offer	Annually in the summer semester	
Duration	1 semester	
Module Coordinator	Track Coordinator Economic and Social Sciences	
Course Lecturer(s)	U. Schneider	
Literature	Draft Book "Forest and Agricultural Sector Analysis" available from instructor and contained literature references	

Course Number	ICSS-M-2.4.3 (63-??)	
Title	**Agent-based Modelling – Theory and Applications in the Social Sciences**	
Learning Outcomes	Students are familiar with agent-based modelling to explore macro phenomena emerging from micro behavior of agents.	
Contents	The seminar provides an introduction to the methodological approach called agent-based modelling. The course considers the theory how to describe, communicate, design, calibrate, and validate agent-based models and presents examples from applications in the social sciences, e.g. climate economics, public economics and sociology.	
Educational Concept	Seminar (2 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	Prior knowledge of programming is not required but highly recommended.	
Exam Framework	Type:	Joint track exam
	Requirements for registration:	$\geq$80% participation
	Language:	English
	Duration/size:	1 hour presentation, 10-15 pages written report
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	28 hours
	Self-study:	32 hours
	Exam Preparation:	30 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 2 of M.Sc. ICSS	
Frequency of Offer	Annually in the summer semester	
Duration	1 semester	
Module Coordinator	Track Coordinator Economic and Social Sciences	
Course Lecturer(s)	J. Scheffran, S. Hokamp	
Literature	Will be announced during the course	

Course Number	ICSS-M-2.4.4 (63-953)	
Title **Learning Outcomes**	**Integrated Climate-Economic Modeling** Students have an overview on integrated climate-economic modeling that supports an assessment of how, when, and to what extent global warming could be mitigated.	
Contents	The status of the scientific arguments behind global warming mitigation targets and instruments is reviewed, covering competing schools within climate economics. The necessary modeling tools are introduced together with a module-adjusted short course on resource economics and economic growth theory.	
Educational Concept	Lectures (2 SWS) in an interactive format (interactive elements: discussion of homework; test exam and discussion)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	Bachelor-level of applied mathematics, climate dynamics, an introduction to welfare economics, and scientific English.	
Exam Framework	Type:	Joint track exam
	Requirements for registration:	Active participation
	Language:	English
	Duration/size:	
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	28 hours
	Self-study:	32 hours
	Exam Preparation:	30 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 2 of M.Sc. ICSS	
Frequency of Offer	Annually in the summer semester	
Duration	1 semester	
Module Coordinator	Track Coordinator Economic and Social Sciences	
Course Lecturer(s)	H. Held	
Literature	Will be announced during the course.	

Module Abbreviation	2.5 CLITECH	
Title	**Technical Skills**	
Learning Outcomes	Students have gained working knowledge in tools used for scientific programming and data analysis or software development.	
Contents	2 courses have to be chosen: 2.5.1 Scientific Software Development (Behrens) 2.5.2 Scientific Programming in Python I (Sadikni) 2.5.3 Scientific Programming in Python II (Sadikni) 2.5.4 Geographic Information Systems and Science (Wehberg) 2.5.5 MATLAB in Earth System Science (Borth, Schubert, Zhu) 2.5.6 Introduction to GAMS (Schneider) 2.5.7 Object-Oriented Programming for Scientists (Sadikni) 2.5.8 Scientific Visualization Course (Brisc)	
Language	English	
Formal Requirements for Participation	See specific announcements for the individual courses	
Recommended Prerequisites	See specific announcements for the individual courses	
Exam Framework	Type:	Course specific exam (pass/fail), as a rule: practicals. Deviations will be announced at the beginning of the courses
	Requirements for Registration:	>80% attendance of the courses
	Language:	English
	Duration/Size:	
Credit Points	3	
Course Type and Usability	Compulsory for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule	
Semester	Semester 2 of M.Sc. ICSS; reference semester 2	
Frequency of Offer	Annually in the summer semester	
Duration	1 semester	
Module Coordinator	Head of SICSS	

Course Number	ICSS-M-2.5.1 (63-962)	
Title	**Scientific Software Development**	
Learning Outcomes	Students know software engineering methods for programming, they are able to use programming related tools, they have become aware of state of the art planning and documentation in software development.	
Contents	Introduction to software engineering: (software life cycle; facts about software engineering; mapping software to hardware) Version Control: (introduction to versioning; using version control systems) Project management: (ticketing and release planning; using wikis and document management, resource planning) Verification and Validation: (testing methodology; automated builds; debugging and how to use debuggers) Technical Documentation: (types of documentations; tools for in-line documentation).	
Educational Concept	Lectures with a lot of practical work and exercises (2 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	Good programming knowledge, basic knowledge in Unix operating systems, some Fortran knowledge	
Exam Framework	Type:	practicals pass/fail
	Requirements for registration:	regular and active participation
	Language:	English
	Duration/size:	
	Weight Factor for Module Grade:	
Credit Points	1.5	
Workload	Campus Study:	28 hours
	Self-study:	17 hours
	Exam Preparation:	0 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 2 of M.Sc. ICSS	
Frequency of Offer	Annually during the lecture-free period	
Duration	1 week block course	
Module Coordinator	Head of SICSS	
Course Lecturer(s)	J. Behrens	
Literature	Will be announced during the course.	

Course Number	ICSS-M-2.5.2 (63-968)	
Title **Learning Outcomes**	**Scientific Programming in Python I** Students have learned the programming language Python from scratch. They got in touch with common scientific libraries for analyzing and plotting geoscientific data.	
Contents	Introduction to Python: data types, control flow statements, data structures, functions, input / output, modules, errors and exceptions, classes. Introduction to scientific libraries like numpy, scipy and matplotlib. This course is designed for novice programmers and will focus on the basics of programming.	
Educational Concept	Lectures with practical training (2 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	none	
Exam Framework	Type:	practicals pass/fail
	Requirements for registration:	regular participation ($> 80\%$)
	Language:	English
	Duration/size:	
	Weight Factor for Module Grade:	
Credit Points	1.5	
Workload	Campus Study:	28 hours
	Self-study:	17 hours
	Exam Preparation:	0 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 2 of M.Sc. ICSS	
Frequency of Offer	Annually during the winter semester	
Duration	1 semester	
Module Coordinator	Head of SICSS	
Course Lecturer(s)	R. Sadikni	
Literature	Material will be provided.	

Course Number	ICSS-M-2.5.3 (63-968)	
Title **Learning Outcomes**	**Scientific Programming in Python II** Students have learned the programming language Python from scratch. They got in touch with common scientific libraries for analyzing and plotting geoscientific data.	
Contents	Introduction to Python: data types, control flow statements, data structures, functions, input / output, modules, errors and exceptions, classes. Introduction to scientific libraries like numpy, scipy and matplotlib. This course is designed for novice programmers and will focus on the basics of programming.	
Educational Concept	Lectures with practical training (2 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	none	
Exam Framework	Type:	practicals pass/fail
	Requirements for registration:	regular participation ($> 80\%$)
	Language:	English
	Duration/size:	
	Weight Factor for Module Grade:	
Credit Points	1.5	
Workload	Campus Study:	28 hours
	Self-study:	17 hours
	Exam Preparation:	0 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 2 of M.Sc. ICSS	
Frequency of Offer	Annually during the winter semester	
Duration	1 semester	
Module Coordinator	Head of SICSS	
Course Lecturer(s)	R. Sadikni	
Literature	Material will be provided.	

Course Number	ICSS-M-2.5.4 (63-652)	
Title **Learning Outcomes**	**Geographic Information Systems and Science** Students know basic GIS concepts, how to create, access and manage geodata and obtain a comprehensive overview to vector and raster related tools and analyses.	
Contents	This course gives a comprehensive overview to the fundamentals of Geographic Information Systems (GIS) and related scientific applications.	
Educational Concept	Lectures with practical training (2 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	none	
Exam Framework	Type:	practicals pass/fail
	Requirements for registration:	regular and active participation
	Language:	English
	Duration/size:	
	Weight Factor for Module Grade:	
Credit Points	1.5	
Workload	Campus Study:	28 hours
	Self-study:	17 hours
	Exam Preparation:	0 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 2 of M.Sc. ICSS	
Frequency of Offer	Annually during the lecture-free period	
Duration	1 week block course	
Module Coordinator	Head of SICSS	
Course Lecturer(s)	J. Wehberg	
Literature	Will be announced during the course.	

Course Number	ICSS-M-2.5.5 (63-963)	
Title **Learning Outcomes**	**MATLAB in Earth System Science: An Introduction** Students can handle the basic operators as well as data and control structures of Matlab and apply those to typical simple problems of data manipulation and visualization in Earth System Science.	
Contents	The course offers an introduction to Matlab as a high-level programming language as well as an introduction to data streaming, analysis and visualization in Matlab with worked examples from Earth System Science	
Educational Concept	Seminar (1 SWS) and exercises (1 SWS). The course consists of lecture units, worked examples and hands-on exercises.	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	Background in geosciences and some experience with structured problem solving typical for natural sciences. Basic knowledge of Linux will be helpful.	

Exam Framework	Type:	practicals pass/fail
	Requirements for registration:	regular and active participation and a report for a worked example
	Language:	English
	Duration/size:	
	Weight Factor for Module Grade:	
Credit Points	1.5	
Workload	Campus Study:	25 hours
	Self-study:	10 hours
	Exam Preparation:	10 hours

Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.
Semester	Semester 2 of M.Sc. ICSS
Frequency of Offer	Annually during the lecture-free period
Duration	1 week block course
Module Coordinator	Head of SICSS
Course Lecturer(s)	H. Borth, S. Schubert, X. Zhu
Literature	Tutorials, worked examples and documentation presented in the official MathWorks Documentation Center (www.mathworks.de $\rightarrow$ support $\rightarrow$ documentation $\rightarrow$ matlab). Further literature or reading will be announced at the beginning of the course.

Course Number	ICSS-M-2.5.6 (63-964)	
Title	**Introduction to GAMS (Generalized Algebraic Modeling System)**	
Learning Outcomes	Students have learned mathematical programming of optimization problems.	
Contents	Overview (capabilities, applicability, requirements, help); basic modelling (representation of mathematical problems, sets, data, variables, equations, conditions, model types, model solving, error detection and correction); output (interpretation, modification, option commands, report writing, export).	
Educational Concept	Exercises in computer lab (2 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	none	
Exam Framework	Type:	practicals pass/fail
	Requirements for registration:	regular and active participation
	Language:	English
	Duration/size:	
	Weight Factor for Module Grade:	
Credit Points	1.5	
Workload	Campus Study:	20 hours
	Self-study:	25 hours
	Exam Preparation:	0 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 2 of M.Sc. ICSS	
Frequency of Offer	Annually during the lecture-free period	
Duration	3 day block course	
Module Coordinator	Head of SICSS	
Course Lecturer(s)	U. Schneider	
Literature	B.A. McCarl, T.H. Spreen: Applied Mathematical Programming Using Algebraic Systems (http://agecon2.tamu.edu/people/faculty/mccarlbruce/books.htm).	

Course Number	ICSS-M-2.5.7 (63-967)	
Title **Learning Outcomes**	**Object-Oriented Programming for Scientists** Students will be familiar with approaches and knowledge of object-oriented programming. They know the basic usage in Python and Matlab.	
Contents	Introduction of basic facts and approaches of Object-oriented Programming: Introduction to object-oriented programming; Principle of object orientation; Advantages to other programming concepts; Objects; Classes; Data types; Methods; Inheritance; Data encapsulation; Polymorphism; Object-oriented software design with UML; OOP in Python; OOP in Matlab	
Educational Concept	Lecture and exercise units (2 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	Basic knowledge in programming	
Exam Framework	Type:	practicals pass/fail
	Requirements for registration:	regular and active participation
	Language:	English
	Duration/size:	
	Weight Factor for Module Grade:	
Credit Points	1.5	
Workload	Campus Study:	28 hours
	Self-study:	17 hours
	Exam Preparation:	0 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 2 of M.Sc. ICSS	
Frequency of Offer	Twice per year during the lecture-free period	
Duration	1 week block course	
Module Coordinator	Head of SICSS	
Course Lecturer(s)	R. Sadikni	
Literature	Material will be provided.	

Course Number	ICSS-M-2.5.8 (63-965)	
Title	**Scientific Visualization Course**	
Learning Outcomes	Upon completion of the course, the student know: the latest techniques used in scientific visualization; hands-on ways to use visualization in research work, publications and presentations; where to locate further visualization resources.	
Contents	Overview of scientific visualization (history, goals, definitions): Color theory and color systems; data representation in scientific visualization (data types and formats, conversion tools, grids - structured and unstructured, scattered data); visualization software and resources; traditional and state-of-the-art visualization techniques; methods of effective use of visualization throughout the stages of research work; data analysis and visual communication; display methods and devices - from computer screen to virtual and immersive 3D worlds.	
Educational Concept	Lectures with practical training (2 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	none	
Exam Framework	Type:	practicals pass/fail
	Requirements for registration:	>80% participation
	Language:	English
	Duration/size:	
	Weight Factor for Module Grade:	
Credit Points	1.5	
Workload	Campus Study:	28 hours
	Self-study:	17 hours
	Exam Preparation:	0 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 2 of M.Sc. ICSS	
Frequency of Offer	Annually during the lecture-free period	
Duration	1 week block course	
Module Coordinator	Head of SICSS	
Course Lecturer(s)	F. Brisc	
Literature	Material will be provided.	

Semester 3: Winter Semester

Module Abbreviation	3.1 CLISEM	
Title	**Climate System Science Seminar**	
Learning Outcomes	Students are able to present aspects of their work in the study project to an audience with similar background but different specialization. Students have an overview of current topics and the state-of-the-art in integrated climate system sciences.	
Contents	Compulsory seminars: 3.1.1 Climate System Science Seminar (Head of SICSS)	
Language	English	
Formal Requirements for Participation	Concurrent participation in module *Climate Study Project*	
Recommended Prerequisites	See specific announcements for the individual courses	
Exam Framework	Type:	Presentation and report
	Requirements for Registration:	>80% attendance of the seminar
	Language:	English
	Duration/Size:	Oral presentation of 20-30 minutes. Report of 3 to 5 pages (1000 to 1500 words).
Credit Points	3	
Course Type and Usability	Compulsory for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule	
Semester	Semester 3 of M.Sc. ICSS; reference semester 3	
Frequency of Offer	Annually in the winter semester	
Duration	1 semester	
Module Coordinator	Head of SICSS	

Course Number	ICSS-M-3.1.1 (63-949)	
Title **Learning Outcomes**	**Climate System Science Seminar** Students are able to present a concept of their work performed as part of the study project to an audience with similar background but different specialization.	
Contents	Seminar presentation and discussion on the pre-thesis work of the ICSS students.	
Educational Concept	Seminar event (1 SWS)	
Language	English	
Formal Requirements for Participation	Concurrent participation in courses *Climate Study Project* and *Scientific Writing*.	
Recommended Prerequisites	none	
Exam Framework	Type:	Presentation and report
	Requirements for registration:	regular and active participation
	Language:	English
	Duration/size:	Oral Presentation of 20-30 minutes. Report of 3 to 5 pages (1000 to 1500 words).
	Weight Factor for Module Grade:	75% presentation and 25% report
Credit Points	3	
Workload	Campus Study:	14 hours
	Self-study:	76 hours
	Exam Preparation:	0 hours
Course Type and Usability	Compulsory for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 3 of M.Sc. ICSS	
Frequency of Offer	Annually in the winter semester, seminar in February	
Duration	1 semester, 3 day seminar event	
Module Coordinator	Head of SICSS	
Course Lecturer(s)	Head of SICSS	
Literature		

Module Abbreviation	3.2 CLISTUDY	
Title	**Climate Study Project**	
Learning Outcomes	Students have gained the necessary background knowledge, as well as methodological, technical and writing skills to begin a master thesis in one of the three tracks.	
Contents	Compulsory courses: 3.2.1 Climate Study Project (ICSS thesis advisors) 3.2.2 Scientific Writing (NN, Hense, NN)	
Language	English	
Formal Requirements for Participation		
Recommended Prerequisites	See specific announcements for the individual courses	
Exam Framework	Type:	Report
	Requirements for Registration:	
	Language:	English
	Duration/Size:	20-25 pages
Credit Points	18	
Course Type and Usability	Compulsory for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule	
Semester	Semester 3 of M.Sc. ICSS; reference semester 3	
Frequency of Offer	Annually in the winter semester	
Duration	1 semester	
Module Coordinator	Head of SCISS	

Course Number	ICSS-M-3.2.1 (63-950)	
Title	**Climate Study Project**	
Learning Outcomes	Students are able to carry individual project studies related to climate system sciences.	
Contents	Projects related to integrated climate system sciences are being performed. Individual research with supervision by advisor in preparation of the M.Sc. thesis.	
Educational Concept	Theoretical and practical training (10 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	none	
Exam Framework	Type:	Report
	Requirements for registration:	regular and active participation
	Language:	English
	Duration/size:	20-25 pages
	Weight Factor for Module Grade:	
Credit Points	15	
Workload	Campus Study:	360 hours
	Self-study:	90 hours
	Exam Preparation:	0 hours
Course Type and Usability	Compulsory for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 3 of M.Sc. ICSS	
Frequency of Offer	Annually in the winter semester	
Duration	1 semester	
Module Coordinator	Head of SICSS	
Course Lecturer(s)	ICSS thesis advisors	
Literature	Will be announced during the project	

Course Number	ICSS-M-3.2.2 (63-966)	
Title	**Scientific Writing**	
Learning Outcomes	Students are able to write accurately and concisely about a scientific topic.	
Contents	The structure of a scientific paper and master thesis. Writing an effective title, effective paragraphs and effective sentences, using effective words and phrases.	
Educational Concept	Comments on the ICSS Seminar report and (optional) early draft versions of the pre-thesis report	
Language	English	
Formal Requirements for Participation	Concurrent participation in the courses *Climate System Science Seminar* and *Climate Study Project*.	
Recommended Prerequisites		

Exam Framework	Type:	report: pass/fail
	Requirements for registration:	participation in the introductory lecture, submission of a rebuttal letter and a sequence of revised versions (as appropriate)
	Language:	English
	Duration/size:	
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	14 hours
	Self-study:	76 hours
	Exam Preparation:	0 hours

Course Type and Usability	Compulsory for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.
Semester	Semester 3 of M.Sc. ICSS
Frequency of Offer	Annually in the winter semester
Duration	1 semester
Module Coordinator	Head of SICSS
Course Lecturer(s)	NN, I. Hense, NN
Literature	

Module Abbreviation	3.3 CLIADD	
Title	**Climate Science Additionals**	
Learning Outcomes	Students have sufficient specialization in one of the 3 tracks.	
Contents	2-3 courses have to be chosen: 3.3.1 Tropical Circulation Systems (Stevens) 3.3.2 Predictability and Predictions of Climate (Baehr) 3.3.3 Ocean Data Assimilation (Baehr, Stammer) 3.3.4 The Asian Monsoon System (Zhu) 3.3.5 Marine Biogeochemical and Ecosystem Modeling (Hense) 3.3.6 Hydrochemical Modeling (Hartmann) 3.3.7 Climate Engineering – Carbon Dioxide Removal and Other Options (Amann) 3.3.8 Using the Eddy Covariance Method for Analyzing Land- Atmosphere Fluxes (Kutzbach, Wille) 3.3.9 Permafrost Soils and Landscapes . . . (Pfeiffer, Kutzbach) 3.3.10 Application of Stable Isotopes . . . (Knoblauch) 3.3.11 Terrestrial Ecosystem Processes within ESMs (Brovkin) 3.3.12 Microeconomics (Perino) 3.3.13 Integrated Assessment Modelling of Global Change (Held, Hokamp) 3.3.14 Decision under Uncertainty in the Integrated Assessment of the Energy-Climate Problem (Held)	
Language	English	
Formal Requirements for Participation	See specific announcements for the individual courses	
Recommended Prerequisites	See specific announcements for the individual courses	
Exam Framework	Type:	Course specific: Written or oral; oral or written report; overall test or component testing. The specific type will be announced at the beginning of the courses
	Requirements for Registration:	Course specific
	Language:	English
	Duration/Size:	Course specific
Credit Points	9	
Course Type and Usability Semester	Compulsory for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule Semester 3 of M.Sc. ICSS; reference semester 3	
Frequency of Offer	Annually in the winter semester	
Duration	1 semester	
Module Coordinator	SICSS Track Coordinators	

Course Number	ICSS-M-3.3.1 (63-952)	
Title **Learning Outcomes**	**Tropical Circulation Systems** Students will have developed a strong understanding of the theoretical underpinnings of major tropical circulation systems, ranging from the Hadley and Walker Cells to the Monsoon, tropical cyclones, and tropical waves and theories for the placement of tropical convergence zones. In so doing they are expected to also develop an idea of areas of contemporary research on this topic	
Contents	Each week a topic (Hadley Cell, Monsoon, Walker Cell, etc.) will be addressed through a discussion of the literature and some lecture material on background concepts. Students are expected to thoroughly read and understand one paper were lecture.	
Educational Concept	Lectures and Paper Discussion (2SWS)	
Language	English	
Formal Requirements for Participation	An understanding of basic concepts in geophysical fluid dynamics, and atmospheric thermodynamics.	
Recommended Prerequisites	Basic courses in physical climatology and radiative transfer	
Exam Framework	Type:	Report and class participation
	Requirements for registration:	
	Language:	English
	Duration/size:	7-12 pages
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	26 hours
	Self-study:	52 hours
	Exam Preparation:	12 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 3 of M.Sc. ICSS	
Frequency of Offer	Annually in the winter semester	
Duration	1 semester	
Module Coordinator	SICSS Track Coordinators	
Course Lecturer(s)	B. Stevens	
Literature	Will be announced during the course	

Course Number	ICSS-M-3.3.2 (63-953)	
Title **Learning Outcomes**	**Predictability and Predictions of Climate** Students will be familiar with the techniques used to investigate predictability and the methods used to make predictions of climate variability at seasonal to decadal timescales with a focus on coupled ocean-atmosphere processes.	
Contents	Introduction to predictability of climate; Lorenz model; determination of predictability; ensemble forecasting; forecast initialization; ensemble initialization; error propagation and assessment of forecast reliability/quality; present understanding of the processes that determine predictability; seasonal to decadal predictions of the climate system.	
Educational Concept	Lectures and research seminar (2 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	none	

Exam Framework	Type:	Will be specified at the beginning of the course
	Requirements for registration:	regular and active participation
	Language:	English
	Duration/size:	
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	28 hours
	Self-study:	32 hours
	Exam Preparation:	30 hours

Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.
Semester	Semester 3 of M.Sc. ICSS
Frequency of Offer	Annually in the winter semester.
Duration	1 semester
Module Coordinator	SICSS Track Coordinators
Course Lecturer(s)	J. Baehr
Literature	Palmer and Hagedorn (Eds.), 2006: Predictability of weather and climate. Additional literature will be announced during the course

Course Number	ICSS-M-3.3.3 (63-751)	
Title **Learning Outcomes**	**Ocean Data Assimilation** Students are familiar with the most basic methods and concepts in inverse modeling and data assimilation with emphasis on applications in the ocean.	
Contents	Topics like the following will be covered: inverse problems, least squares methods, generalized inverse, sequential data assimilation, optimal interpolation, Kalman Filter, adjoint method, correction of model dynamics through data assimilation.	
Educational Concept	Lectures (2 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	Basic knowledge in dynamical oceanography, modeling fluid dynamics, and algebra	
Exam Framework	Type:	Written exam or oral/written report on an agreed topic
	Requirements for registration:	regular and active participation
	Language:	English
	Duration/size:	
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	28 hours
	Self-study:	32 hours
	Exam Preparation:	30 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 3 of M.Sc. ICSS	
Frequency of Offer	Annually in the winter semester.	
Duration	1 semester	
Module Coordinator	SICSS Track Coordinators	
Course Lecturer(s)	J. Baehr, D. Stammer	
Literature	Wunsch, C., 2006: Discrete Inverse and State Estimation Problems	

Course Number	ICSS-M-3.3.4 (63-885)	
Title **Learning Outcomes**	**The Asian Monsoon System** Students have developed an understanding of characteristics of the Asian monsoon and the related dynamical systems and mechanisms. Specifically, they have developed a holistic view of the monsoon system in the context of global climate systems, in particular, regarding its interaction with other large-scale climate modes (ENSO, MJO). Students are able to calculate various monsoon indices and identify the related characteristic circulation patterns from reanalysis data or numerical model outputs.	
Contents	Monsoon definitions; circulation characteristics, centers of action, and related thermal-dynamical processes of the Asian (summer and winter) monsoon systems; key elements of the Asian Monsoon (AM) systems such as the Tibetan Plateau topographic forcing; literature review on the AM and the Tibetan uplift; interaction of the AM with climate modes like ENSO and MJO (Madden-Julian Oscillation) and its evolution in a warmer climate.	
Educational Concept	Lectures (2 SWS)	
Language	English	
Formal Requirements for Participation	Successful participation in the course *Introduction to Statistics*.	
Recommended Prerequisites	none	
Exam Framework	Type:	Will be specified at the beginning of the course
	Requirements for registration:	regular and active participation
	Language:	English
	Duration/size:	
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	28 hours
	Self-study:	32 hours
	Exam Preparation:	30 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 3 of M.Sc. ICSS	
Frequency of Offer	Annually in the winter semester.	
Duration	1 semester	
Module Coordinator	SICSS Track Coordinators	
Course Lecturer(s)	X. Zhu	
Literature	Will be announced during the course	

Course Number	ICSS-M-3.3.5 (63-954)	
Title **Learning Outcomes**	**Marine Biogeochemical and Ecosystem Modeling** Students are able to use the "modelling language", to select the most appropriate methods and approaches for a number of specific applications, to formulate simple ecosystem models, to analyze and present the results. They have learned to identify and evaluate model strengths and weaknesses.	
Contents	The basics of model structures are explained, including factors and processes which are generally considered in aquatic ecosystem and biogeochemical models. Focus will be on plankton dynamics: growth and mortality processes of phyto- and zooplankton. Examples of biogeochemical models based on carbon and nitrogen are presented.	
Educational Concept	Lectures (1 SWS), exercises (1 SWS), seminars (2 SWS)	
Language	English	
Formal Requirements for Participation	Good knowledge of a programming language and a visualization tool. Successful completion of the course *Dynamics of Marine Ecosystems,* or individual permission by the lecturer	
Recommended Prerequisites	Basic knowledge in ecosystem dynamics and theoretical ecology	
Exam Framework	Type:	Will be announced at the beginning of the course
	Requirements for registration:	>80% participation in the weekly exercises and seminars
	Language:	English
	Duration/size:	
	Weight Factor for Module Grade:	
Credit Points	6	
Workload	Campus Study:	64 hours
	Self-study:	90 hours
	Exam Preparation:	26 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 3 of M.Sc. ICSS	
Frequency of Offer	Annually in the winter semester	
Duration	First half of the semester	
Module Coordinator	SICSS Track Coordinators	
Course Lecturer(s)	I. Hense	
Literature	Will be announced during the course.	

Course Number	ICSS-M-3.3.6 (63-955)	
Title **Learning Outcomes**	**Hydrochemical Modeling** Students can apply hydrogeochemical models to analyse natural as well as man made impacts on the composition of natural waters. Students are capable to model mineral dissolution processes, to identify equilibrium conditions of an aquatic system. They know how to use hydrochemical modeling software to analyse climate relevant matter in the water system (e.g. CO_2).	
Contents	Theory of hydrochemical equilibrium models and application of PHEEQC to solve scientific questions related to the climate system. This includes determination of saturation indices, adjustment of equilibria/disequilibria for minerals and gases, mixing of waters (for example in the coastal zone), modeling the effect of temperature on hydrochemical reactions, reactions in open and closed systems, calculation of the partial pressure of climate relevant gases in natural waters, discussion of case studies.	
Educational Concept	Lectures and case study calculations (2 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	Successful completion of the course *Chemistry of Natural Waters*	
Exam Framework	Type:	Will be announced at the beginning of the course
	Requirements for registration:	regular and active participation
	Language:	English
	Duration/size:	
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	28 hours
	Self-study:	40 hours
	Exam Preparation:	22 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule. Maximum number of participants: 10	
Semester	Semester 3 of M.Sc. ICSS	
Frequency of Offer	Annually in the winter semester	
Duration	1 semester	
Module Coordinator	SICSS Track Coordinators	
Course Lecturer(s)	J. Hartmann	
Literature	Will be announced during the course.	

Course Number	ICSS-M-3.3.7 (63-358)	
Title **Learning Outcomes**	**Climate Engineering – Carbon Dioxide Removal and Other Options** The goal of this lecture is to become acquainted with methods of climate engineering as it grows more important in the climate change discourse.	
Contents	Climate engineering, the deliberate and large-scale intervention in the Earth's climatic system, has been in discussion as an option to battle climate change for a few years now. This lecture will address this highly topical issue by introducing several options that are envisioned to be potentially deployed, with a clear focus on carbon dioxide removal. Strategies for solar radiation management will be presented briefly. Benefits and side effects from local to global scales will be shown for matter and energy fluxes. At the same time, the matter is highly controversial on an ethical level. Issues like governance, moral hazard and intergenerational justice will be succinctly addressed.	
Educational Concept	Lectures (2 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	Basic understanding of the carbon cycle and the biogeochemical processes involved.	
Exam Framework	Type:	report
	Requirements for registration:	regular and active participation
	Language:	English
	Duration/size:	10-15 pages
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	28 hours
	Self-study:	31 hours
	Exam Preparation:	31 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule	
Semester	Semester 3 of M.Sc. ICSS	
Frequency of Offer	Annually in the winter semester	
Duration	1 semester	
Module Coordinator	SICSS Track Coordinators	
Course Lecturer(s)	T. Amann	
Literature	Will be announced during the course	

Course Number	ICSS-M-3.3.8 (63-321)	
Title	**Using the Eddy Covariance Method for Analyzing Land- Atmosphere Fluxes**	
Learning Outcomes	Students have gained knowledge about the theoretical basics of the micrometeorological eddy covariance approach. They have learned how an eddy covariance flux measurement system is set-up and maintained, and how the data is recorded. They will be able to handle and process the complex and massive rawdata streams to derive the energy and matter fluxes. They obtain competence to apply the micrometeorological eddy covariance approach for the analysis of soil-vegetation- atmosphere fluxes of energy, water and carbon on the landscape scale.	
Contents	Introduction to the micrometeorological eddy covariance theory; requirements for instrumentation and measurement site; set-up and maintenance of an eddy covariance flux measurement system; introduction to the flux calculation software EdiRe; basic flux calculation from rawdata streams; flux corrections; data visualisation; quality control; application of eddy covariance data for the investigation of land-atmosphere exchange fluxes of energy, water and carbon.	
Educational Concept	Seminar (1 SWS), exercises including a field trip (1 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	Basic knowledge of boundary layer meteorology.	
Exam Framework	Type:	Written report
	Requirements for registration:	regular and active participation
	Language:	English
	Duration/size:	4 pages
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	28 hours
	Self-study:	36 hours
	Exam Preparation:	26 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 3 of M.Sc. ICSS	
Frequency of Offer	Annually in the winter semester	
Duration	1 semester	
Module Coordinator	SICSS Track Coordinators	
Course Lecturer(s)	L. Kutzbach, C. Wille	
Literature	Will be announced during the course	

Course Number	ICSS-M-3.3.9 (63-319)	
Title	**Permafrost Soils and Landscapes in the Climate System**	
Learning Outcomes	Students have gained knowledge about permafrost landscapes, soils and vegetation and their role in the climate system. A focus will be set on periglacial and cryopedogenetic processes. The students improve their understanding of environmental and climatic changes in arctic region. They obtain competence for the evaluation of ecosystem functions and resources of permafrost landscapes.	
Contents	High-latitude terrestrial processes in periglacial landscapes; permafrost and active layer processes; soils of different permafrost landscapes; cryosols in the international soil classifications; patterned-ground processes, frost-action processes, cryoturbation; tundra vegetation, boreal forests and peatlands, tree- and shrubline dynamics; carbon in permafrost soils and sediments; role of high-latitude terrestrial systems in the global climate system; impact of climate and land use change on arctic and boreal ecosystems and permafrost; observational versus model results of permafrost changes due to climate change.	
Educational Concept	Lectures (2 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	Basic knowledge of soil science	

Exam Framework	Type:	Written exam
	Requirements for registration:	regular and active participation
	Language:	English
	Duration/size:	60 minutes
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	28 hours
	Self-study:	36 hours
	Exam Preparation:	26 hours

Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.
Semester	Semester 3 of M.Sc. ICSS
Frequency of Offer	Annually in the winter semester
Duration	1 semester
Module Coordinator	SICSS Track Coordinators
Course Lecturer(s)	E.-M. Pfeiffer, L. Kutzbach
Literature	Will be announced during the course

Course Number	ICSS-M-3.3.10 (63-322)	
Title **Learning Outcomes**	**Application of Stable Isotopes in Terrestrial Ecosystems** Students will be familiar with the potential of stable isotope measurements for studying element fluxes in terrestrial ecosystems. They will be able to interpret natural carbon isotope signatures in soils, vegetation and the climate relevant trace gases CO_2 and methane. They will also be able to use ^{13}C-tracers for quantifying carbon turnover of different carbon pools in the environment.	
Contents	Introduction to the fundamentals of stable isotope biogeochemistry. Laboratory experiments for quantifying carbon fluxes in the environment, based on natural abundance measurements and isotope tracers. Calculation of CO2 and methane-fluxes from different carbon pools.	
Educational Concept	Practical laboratory course complemented by introductory lectures and exercises on data analysis (2 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	Fundamental biogeochemical knowledge	
Exam Framework	Type:	Will be announced at the beginning of the course
	Requirements for registration:	regular and active participation
	Language:	English
	Duration/size:	
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	28 hours
	Self-study:	47 hours
	Exam Preparation:	15 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule. Maximum number of participants: 10	
Semester	Semester 3 of M.Sc. ICSS	
Frequency of Offer	Annually in the winter semester	
Duration	1 semester	
Module Coordinator	SICSS Track Coordinators	
Course Lecturer(s)	C. Knoblauch	
Literature	Sharp, Z., 2007. Principles of stable isotope geochemistry. Pearson Prentice Hall, Upper Saddle River. Hoefs, J. (2008). Stable isotope geochemistry. Springer, Berlin. Further literature will be announced during the course.	

Course Number	ICSS-M-3.3.11 (63-959)	
Title **Learning Outcomes**	**Terrestrial Ecosystem Processes within Earth System Models** Students have theoretical knowledge and practical skills in terrestrial ecosystem modeling and feedbacks between vegetation and climate and understand and are able to utilize terrestrial biosphere models used for future climate projections.	
Contents	The course starts with introduction into main biological and biophysical processes: photosynthesis, land surface hydrology and biophysics, carbon cycle, and plant ecology. The main focus is given on current state-of-the-art in modeling of these processes within Earth System models. Examples of topics include modeling of landuse effects on terrestrial ecosystem and biogeochemistry; modeling of vegetation dynamics under changed climate; assessment of feedbacks between terrestrial ecosystems and climate on multiple spatial and temporal scales. Biogeophysical and biogeochemical effects of land cover and landuse change are analyzed for future climate as well for several chosen paleo climates.	
Educational Concept	Lectures (2 SWS) and practical exercises (1 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	Basic knowledge of biological processes; basic skills in programming on Python, R, or MatLab for solving simple equilibrium or dynamical system equations.	

Exam Framework	Type:	oral
	Requirements for registration:	regular and active participation
	Language:	English
	Duration/size:	
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	42 hours
	Self-study:	32 hours
	Exam Preparation:	16 hours

Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule
Semester	Semester 3 of M.Sc. ICSS
Frequency of Offer	Annually in the winter semester
Duration	1 semester
Module Coordinator	SICSS Track Coordinators
Course Lecturer(s)	V. Brovkin
Literature	Will be announced during the course

Course Number	ICSS-M-3.3.12 (23-36.905.142)	
Title	**Microeconomics**	
Learning Outcomes	Students have learned the tools to understand and conduct applied microeconomic analysis.	
Contents	This course covers key concepts in the areas of consumer and producer theory, market equilibria, welfare analysis and game theory. It provides both intuition and formal treatment of standard microeconomic theory supplemented by insights from behavioral economics.	
Educational Concept	Lectures (2 SWS) and Practical (1 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	Familiarity with basic microeconomic concepts and simple analytical optimization techniques	
Exam Framework	Type:	written exam
	Requirements for registration:	none
	Language:	English
	Duration/size:	60 minutes
	Weight Factor for Module Grade:	
Credit Points	6	
Workload	Campus Study:	42 hours
	Self-study:	120 hours
	Exam Preparation:	18 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 3 of M.Sc. ICSS	
Frequency of Offer	Annually in the winter semester	
Duration	1 semester	
Module Coordinator	SICSS Track Coordinators	
Course Lecturer(s)	G. Perino	
Literature	Gravelle, H. and R. Rees, 2004, Microeconomics, 3rd ed. Pearson; Bowles, S., 2006, Microeconomics: Behavior, Institutions, and Evolution, Princeton University Press	

Course Number	ICSS-M-3.3.13 (63-961)	
Title	**Integrated Assessment Modelling of Global Change**	
Learning Outcomes	Students have gained a general understanding of integrated assessment models of global change.	
Contents	The seminar provides an introduction to integrated assessment modelling of global change. The course considers climate engineering, Negishi-weighting and delayed climate policy with a view to their implementation in the integrated assessment models DICE, RICE, MIND and REMIND.	
Educational Concept	Seminar (2 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	Bachelor-level of applied mathematics and scientific English. Prior knowledge of programming is not required but highly recommended.	
Exam Framework	Type:	Oral presentation and written report
	Requirements for registration:	$\geq$80% participation in the seminar
	Language:	English
	Duration/size:	1 hour presentation, 10-15 pages written report
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	28 hours
	Self-study:	32 hours
	Exam Preparation:	30 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule	
Semester	Semester 3 of M.Sc. ICSS	
Frequency of Offer	Annually in the winter semester	
Duration	1 semester	
Module Coordinator	SICSS Track Coordinators	
Course Lecturer(s)	H. Held, S. Hokamp	
Literature	Will be announced during the course	

Course Number	ICSS-M-3.3.14 (22-31.000)	
Title	**Decision under Uncertainty in the Integrated Assessment of the Energy-Climate Problem**	
Learning Outcomes	Students will have obtained the pre-requisites to start a master thesis within climate-economic modeling that is dealing with mitigation, impact or adaptation issues under system response uncertainty. This includes a treatment of uncertainty and interpretation of model results. The outcomes of and the key assumptions behind some major modeling assessments within the climate policy arena will have been obtained during the course.	
Contents	Treatment of uncertainty in climate-economic modeling with respect to climate and the techno-economic system properties as well as global warming impacts. In-depth discussion of model assumptions including underlying theories within macro-economics as well as climate science and land use economics. Treatment of uncertainty including stylized decision under (predominantly epistemic) uncertainty, made up by uncertain system properties/model parameters.	
Educational Concept	Interactive lectures (4 SWS)	
Language	English	
Formal Requirements for Participation	Successful completion of the course *Integrated Climate-Economic Modeling* or Master of Economics course *Climate dynamics and climate economics* or individual permission by the lecturer.	
Recommended Prerequisites	Bachelor-level of applied mathematics and scientific English.	
Exam Framework	Type:	Will be announced at the beginning of the course
	Requirements for registration:	regular and active participation
	Language:	English
	Duration/size:	
	Weight Factor for Module Grade:	
Credit Points	6	
Workload	Campus Study:	56 hours
	Self-study:	64 hours
	Exam Preparation:	60 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule	
Semester	Semester 3 of M.Sc. ICSS	
Frequency of Offer	Annually in the winter semester	
Duration	1 semester	
Module Coordinator	SICSS Track Coordinators	
Course Lecturer(s)	H. Held	
Literature	Will be announced during the course	

Semester 4: Summer Semester

Module Abbreviation	4.0 CLITHESIS	
Title	**M.Sc. Thesis "Integrated Climate System Sciences"**	
Learning Outcomes	The graduate has demonstrated the ability to prepare and to present an innovative M.Sc. thesis in a specific disciplinary or interdisciplinary field of climate system sciences.	
Contents	Practical work, writing the master thesis and oral presentation of the master thesis (ICSS thesis advisors; 30 CP)	
Language	English	
Formal Requirements for Participation	Completion of 60 CP of the M.Sc. ICSS	
Recommended Prerequisites	See specific announcements for the individual courses	
Exam Framework	Type:	M.Sc. thesis (80% of the grade) and oral presentation (20% of the grade)
	Requirements for Registration:	
	Language:	English
	Duration/Size:	maximum 60 minutes (oral presentation: 20 minutes, questions from the examiners: 20 minutes, and questions from the audience: 20 minutes)
Credit Points	30	
Course Type and Usability	Compulsory for M.Sc. ICSS	
Semester	Semester 4 of M.Sc. ICSS; reference semester 4	
Frequency of Offer	Annually in the summer semester	
Duration	1 semester	
Module Coordinator	Head of SICSS	